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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY.
B. T. GALLOWAY, Chief.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.
ALBERT F. WOODS, Pathologist and Physiologist.

THE RELATION OF LIME AND MAGNESIA TO PLANT GROWTH.

I. LIMING OF SOILS FROM A PHYSIOLOGICAL STANDPOINT.

By OSCAR LOEW, *Expert in Physiological Chemistry.*

II. EXPERIMENTAL STUDY OF THE RELATION OF LIME AND MAGNESIA TO PLANT GROWTH.

By D. W. MAY, *Of the Office of Experiment Stations.*

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LETTER OF TRANSMITTAL.

BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., July 16, 1901.

SIR: I transmit herewith the manuscript submitted from the office of the Pathologist and Physiologist of a paper entitled The Relation of Lime and Magnesia to Plant Growth, by Dr. Oscar Loew and Mr. D. W. May, and respectfully recommend that it be published as Bulletin No. 1 of this Bureau.

Respectfully,
B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

Although liming of soils has been practiced for ages and is fairly well understood from the chemical and physical standpoints, comparatively little has been done toward determining the exact physiological explanation of some of the beneficial and injurious effects of liming on the growth of crops. The physiological rôle of calcium and magnesium salts was briefly discussed in Bulletin No. 18 of this office on the Physiological Rôle of Mineral Nutrients. In the present bulletin are brought together many valuable observations on the general subject of liming, especially from the standpoint of the plant. The work, though preliminary, shows quite clearly that magnesium salts are poisonous to our ordinary crops unless accompanied by readily available lime compounds. Under the direction of Dr. Loew, Mr. May, of the Office of Experiment Stations, endeavored to determine experimentally the proper ratio of lime and magnesia for certain crops and soils. The results of these investigations warrant the statement that the amount of available lime and magnesia should be about equal in order to insure maximum growth for most crops. The subject is presented at this time with the hope that it may stimulate investigations along these lines, so important to agriculture. We are under obligations to the Bureau of Chemistry for the chemical analysis of some of the soils and other material used, and to the Bureau of Soils for physical analyses. The manuscript of this bulletin was submitted for publication nearly a year ago, but it has not been practicable to print it until the present time.

ALBERT F. WOODS.

OFFICE OF THE PATHOLOGIST AND PHYSIOLOGIST,
Washington, D. C., June 17, 1901.

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THE RELATION OF LIME AND MAGNESIA TO PLANT GROWTH.

I. LIMING OF SOILS FROM A PHYSIOLOGICAL STANDPOINT.

By Oscar Loew,
Expert in Physiological Chemistry.

INTRODUCTION.

The beneficial effect of slaked lime and gypsum in crop production has been known since the early ages. The old Romans as well as the Japanese and Chinese were well acquainted with the practice of liming. The effects, however, were not uniform either on different soils or for different crops, and damage was sometimes incurred by overliming. It is a question of great importance to the farmer to be able to ascertain when his soil needs liming, and how much of the lime or lime compounds to apply; also whether slaked lime, carbonate of lime, or sulphate of lime is the most suitable form, and whether magnesian limestone must be excluded. The quantities of lime required vary, according to circumstances and the nature of the crop, from 500 to 6,000 pounds per acre. Boggy and clay lands require more lime than other soils. It is preferable to add moderate quantities at comparatively short intervals (every three to six years) rather than a very large quantity at once. Heavy soils may be made more porous by the use of slaked lime, and fine sandy soils may gain in firmness, while soils with an acid reaction may become profitably neutralized.

The decomposition of humus in soils is hastened by lime, its nitrogen being liberated as ammonia and becoming available to the plant either as ammonia or as nitrates after nitrification. The process of nitrification is also promoted by the presence of lime. On sour, boggy lands marsh plants can easily be replaced by forage plants after an application of lime. Liming also has great importance in connection with the raising of live stock, since the formation of bone is imperfect where their food is too poor in lime. Again, certain parasitic fungi and insects in the soil are easily killed by the alkaline properties of burnt lime. Lime and gypsum can also in certain cases release such potash in the soil as is still unavailable. This, as well as the enhanced root hair production under the influence of the increased amount of lime, accounts for the greater absorption of potash by the plant on soils rich in lime.

Although for several reasons the burnt lime is superior to carbonate of lime, and even in some cases mentioned can not be replaced by the latter, still there are instances where finely pulverized carbonate of lime can be applied directly with great success, especially on sandy soil.[1] In many other cases the sulphate of lime (gypsum) is the most favorable form, especially when the amount of sulphates in the soil is very small, it often sinking far below 0.1 per cent.

Gypsum furthermore acts very beneficially in preventing the evaporation of ammonia as ammonium carbonate from stable manure by preserving the ammonia as sulphate. Its very beneficial action for many leguminous crops may be especially mentioned.[2]

Slaked lime is the remedy for correcting an acid reaction, while gypsum is the remedy for correcting an alkaline reaction of soils. To soils of certain arid regions of the far West which contain sodium carbonate, rendering them unfit for raising any crops, Hilgard has proposed an addition of gypsum. The gypsum acts upon the sodium carbonate, transforming this into the less injurious sodium sulphate, while the gypsum itself is transformed into calcium carbonate.

While all these applications of lime and lime compounds[3] are well known, a special case, the correction of the injurious effects of a high magnesia content, will be discussed and experiments described in the second part of this report by Mr. D. W. May, a subject which hitherto has not been taken practically into consideration.

INJURIOUS ACTION OF MAGNESIUM SALTS.

An excess of magnesia acts injuriously on plants, an observation made frequently and even long ago. The increase of lime is the only decisive remedy. The plants thrive best when the ratio of lime to magnesia does not pass certain limits. Too little magnesia in relation to lime may retard development, while too much magnesia in relation to lime may injure the crop still more.

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[1] Various authors place the minimum limit of lime in a soil for good returns at 1 per cent, although satisfactory crops have been raised on clay soils with 0.3 per cent, and on sandy soils with 0.1 per cent lime.

A case may be mentioned where liming proved of immense benefit on soil that contained 0.55 per cent lime. "A percentage of gain of 10,000 in beets" was produced as compared with the unlimed soil. Here it was certainly not the physiological rôle of the lime, but an essential improvement of the soil (neutralization, etc.), which led to this result. This case was observed in Rhode Island and described by Wheeler, Hartwell, and Sargent. (Journ. of Amer. Chem. Soc., 1900, p. 153).

A too heavy application of burnt lime on certain soils might destroy not only noxious parasites but also the useful root bacteria of the Leguminosæ. Reports referring, however, to different soils are still contradictory on this point.

[2] The annual amount of gypsum consumed for fertilizing purposes in the United States is estimated by Dr. H. W. Wiley as 75,000 tons.

[3] The question of liming and of fertilizing in general is fully treated in F. H. Storer's "Agriculture in Some of its Relations to Chemistry," New York, 1897, seventh edition.

In drawing inferences from agricultural experiments much attention should be paid to all conditions that might possibly have an influence. For example, while one author reports that a deficiency of lime will cause yellow spots to develop on the leaves of the sugar beet, and consequently decrease the yield of sugar, another asserts that beets richest in lime are poorest in sugar.[1] In such cases it is necessary to ascertain also the amount of the other nutrients, since too much magnesia may influence the results just as certainly as a reduced amount of potash.

In another instance it is reported that calcium nitrate is a less favorable source of nitrogen than sodium nitrate, an observation which may have been made on soils rich in lime and too poor in magnesia, otherwise it would be difficult to understand, since experiments with water cultures have shown calcium nitrate to be an excellent nutrient.

As early as 1814 Davy discussed the question why magnesia sometimes acts injuriously on crops. He wrote: "It has long been known to farmers in the neighborhood of Duncaster that lime made from certain limestone applied to the land often injures the crop considerably. This lime contained magnesia. On mixing some calcined magnesia with soil in which different seeds are sown, it is found that they either die or vegetate in a very imperfect manner." He also states that "lime from magnesian limestone may be applied in large quantities to peats, and where lands have been injured by the application of too large a quantity of magnesian lime peat will be a proper and efficient remedy."[2]

An injurious action was observed with the limestone from quarries near Belvidere, N. J., while other limestones from near Oxford, some distance off, showed very beneficial effects on the same field. The difference between the effects was so striking that it was considered of some importance to investigate the cause. Samples of the two limestones were therefore sent to the U. S. Department of Agriculture, where they were analyzed, with the result that the *injurious limestones* were found to contain 38 to 42 per cent of magnesium carbonate, while the *beneficial limestone* contained not quite 1 per cent of this substance.[3] The explanation, however, that the injurious effects of burnt magnesian limestone are due mainly to the fact that the caustic magnesia turns much more slowly into carbonate than the caustic lime can not be the correct one, neither can the hypothesis be accepted that the injurious effect is due to the formation of hydraulic cement in the soil, since the effect is less noxious on clay soil than on sandy soil, while just the reverse should be expected if that hypothesis were correct.

Very injurious effects have been reported from manuring with precipitated magnisium carbonate, these being ascribed, however, to the change in the mechanical conditions of the soil.[1] Ad. Mayer[2] mentions sterility in a soil rich in magnesia. On the other hand Heiden[3] states some instances where magnesite and even magnesium sulphate exerted a beneficial effect. Kellner[4] reports a beneficial effect from magnesian limestone,[5] and Larbaletrier and Malpeaux[6] describe a case in which magnesium sulphate proved very efficient.

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[1] Hollrung, Die Zuckerindustrie, 1898.

[2] Elements of Agricultural Chemistry, 2d ed., p. 322.

[3] Report of the Commissioner of Agriculture, Washington, D. C., 1876, p. 142.

Just as contradictory are the reports on the effects of the application of kainit and carnallit, both of which contain salts of potassium and magnesium. The former, however, contains more potassium sulphate than the latter. The effects were frequently found to be injurious when these salts were applied in the spring, while the application in the autumn proved beneficial. Thus Fleischer[7] observed that kainit yielded a 5 per cent larger crop of potatoes when applied in the autumn than when applied in the spring. Other observers[8] reported a decrease in the percentage of starch in potatoes when kainit was applied in the late spring and also claimed that the quality was impaired. Liebenberg[9] finally reports a decrease in the yield of meadows when kainit was applied even in the autumn. In the latter case the perennial roots of the grasses came directly in contact with the fresh fertilizer, while in the previous cases the rains of winter had a chance to wash out or modify the injurious magnesium salt before the crops were planted or seeds were sown. Other authors[10] also report an injurious effect from kainit on meadows, no matter whether applied alone or in conjunction with other fertilizers. However, very many favorable results from the use of kainit on other soils and other crops have been published. Schultz-Lupitz has observed that the injurious effects of the crude potassium salts of Stassfurt (kainit, carnallit, etc.) can be counteracted by liming the soils, but he gave no explanation for this interesting fact. That the application of lime would be in such cases the proper remedy was inferred by the writer[11] from his theory before he knew of the successful experiments of the author just mentioned. It was claimed at that time that the occasional injury caused by the Stassfurt salts was due to their chlorid content, but this is certainly only a subordinate cause. The evil effects are mainly due to their high magnesia content, which will do little harm on soils rich in lime and poor in magnesia, but produces much injury on soils poor in lime rather than in magnesia. The more magnesia in relation to lime present in a soil the more injurious a certain additional quantity of magnesium compounds will prove. With the Stassfurt salts containing magnesium sulphate and chlorid this must be much more evident when they are applied in spring than when applied in autumn, since during the winter a part of the magnesium salts can be washed out as already stated or else turned into the less noxious carbonate. To foretell whether magnesium limestone or the crude salts of Stassfurt would prove to be injurious manures the analysis of the soil would give the proper answer.

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[1] Centralbl. f. Agriculturchemie, 1870.

[2] Vorlesungen, 3d ed., Vol. II, p. 111. Dejardin reports that an increase of the magnesia content in the soil favors the resistance of the vine to Phylloxera, but this remedy applied to a soil poor in lime may prove dangerous to the plants. On the other hand Wheeler reports that liming the soil promotes the scab of the potato. See also Bul. No. 18, U. S. Dept. Agr., Div. Veg. Phys. and Path.

[3] Landw. Vers. Stat., 1869; also Pincus, ibid., 1868, p. 402.

[4] Sächsische Landw. Zeitsch., 1895, No. 24.

[5] Similar results were reported by Völker in England (Griffiths, Treatise on Manure, 1889, p. 235), and Muntz and Girard in France (Les Engrais, 1891, p. 333), and finally by Patterson in Maryland (Bul. No. 66, of the Md. Agr. Ex. Sta., p. 130).

[6] Centralbl. f. Agriculturchemie, 1896, p. 434.

[7] Bot. Jahresber. f. 1886.

[8] Jahresber. f. Agriculturchemie, 1896, p. 222.

[9] Ibid., p. 219.

[10] Ibid., p. 216.

[11] Landw. Vers. Stat., 1892.

The total amount of lime contained in the earth's crust is larger than that of magnesia. The calculation of F. W. Clarke gives as approximate numbers: Lime, 5.29 per cent; magnesia, 4.49 per cent; or, calcium, 3.77 per cent; magnesium, 2.68 per cent. But since the compounds of these elements are not uniformly distributed through the earth's crust, regions exist in which magnesia predominates over lime and others in which lime predominates over magnesia. Manifold variations have indeed been observed. Frequent manuring has, of course, changed these proportions from olden times in the uppermost stratum of the cultivated parts. The dung of animals fed with seeds, such as, for example, maize, oats, and barley, will of course be relatively richer in magnesia than that of animals fed mainly on grass, straw, and various other foliage. The latter manure will contain relatively more lime than the former. Thus, even without having recourse to direct liming, the lime content of cultivated land is often unintentionally increased. In the average fresh barnyard manure there is contained, according to Ville, 80 per cent of water, and among the mineral constituents 0.56 per cent lime and 0.24 per cent magnesia, forming a ratio of 1:0.43.

But while in the crust of the earth as a whole, as well as in most of the spring waters, lime predominates over magnesia, the reverse is observed in the oceans. Sea water contains about 3½ per cent of soluble salts in the following proportions: Sodium chlorid, 78; magnesium chlorid, 11; magnesium sulphate, 5; calcium sulphate, 4; potassium sulphate, 2; traces of iodides, bromides, phosphates, etc.[1]

---

[1] Marret calculates the following amounts for 1,000 parts of sea water (quoted by Liebig, Agriculturchemie.)

Sodium chlorid	26.660
Sodium sulphate	4.660
Potassium chlorid	1.232
Magnesium chlorid	5.152
Calcium sulphate	1.500

In the sea water, therefore, we find a proportion of lime to magnesia of approximately 1:3.8, a ratio which would prove injurious for many land plants in water culture. The marine plants, such as diatoms and fucoids, which in all probability require lime for building up certain of their organized structures, must then have means of accumulating lime compounds in order to counteract an injurious influence of the magnesium compounds entering their cells. Indeed, the ashes of marine algæ show more lime than magnesia, as seen from the following:[1]

Percentage of lime and magnesia in marine plants.

Marine plants.	Percentage of lime.	Percentage of magnesia.
Fucus vesiculosus	9.7	7.1
Fucus nodosus	12.8	10.9
Fucus serratus	16.3	11.6
Laminaria digitata	11.8	7.4

It is well known that a high lime content of the soil favors some plant species more than others, and may even injure certain plants, as the yellow lupin. According to Heinrich,[2] a soil containing 0.46 per cent carbonate of lime will injure the lupin, while 0.5 per cent carbonate of magnesia will prevent its development entirely. Hilgard mentions for the southern part of the United States the linden tree, wild plum tree, and the tulip tree (Liriodendron) as indicative of a soil rich in lime.[3] On the other hand, the southern pines and certain kinds of oak and Vaccinium are indicative of a lack of lime in the soil.[4] With certain other plants some variations in growth depend on the abundance or deficiency of lime in the soil, as Hilgard has pointed out for *Quercus ferruginea* and *Q. obtusiloba.* This author has also called attention to the lower growth but richer yield in seeds and fruits on soils with a high lime content. But, on the other hand, a deficiency of lime may also reduce the size of certain organs. Thus the leaves of young pine trees reach only half the normal length when lime salts are deficient, as Honda and the writer have observed.[5]

It is a natural and logical conclusion that an analysis of soil properly made with regard to the absorbing capacities of the plant roots must yield the means to properly estimate the quality of the soil. Such an analysis must not only regard the absolute quantities of phosphoric acid, sulphuric acid, potassa, lime, magnesia, iron, and nitrogen compounds, but must also consider the fineness or coarseness of the division of the nutritive materials and their solubility in dilute organic acids. But the writer must add that there is another important factor in the valuation of soils, and that is the ratio of the easily assimilable amounts of lime and magnesia in the finer particles. Many attacks have been made upon the use of analyses of soil for purposes of valuation, but this opposition can only relate to certain analyses, such as made in the old method of treating the soil with concentrated hydrochloric acid.[1] Such analyses will not show exactly the amount of nutrients available for the next crop, but mainly indicate the whole amount of nutrients available within a longer period.

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[1] Gödechens, Ann. Chim. Pharm., 1854, Vol. LIV.

Some marine algæ, such as certain members of the Florideæ, exert a powerful attraction upon the lime salts (by probably containing certain organic acids yielding insoluble lime salts), depositing much calcium carbonate in the cell walls.

[2] Jahresber., f. Agr. Chem., 1896, p. 239.

[3] In Europe *Gentiana ciliata* is one of the characteristic lime-soil plants.

[4] The coast pine (Strand Kiefer) can grow in Europe only on soil poor in lime (Grandeau and Fliche, 1878).

[5] Bull. College of Agr., Tokyo, Vol. II, No. 8.

Every farmer ought to know the ratio of the easily assimilable portion of lime to magnesia in his soil, as with such knowledge he can tell when liming is needed and if magnesian limestone will prove injurious. Soils with much magnesia are more to be feared than those with too little. There may be soils with but little available magnesium carbonate which still produce excellent crops, for in this connection it must be remembered that water containing carbonic acid can dissolve more magnesium carbonate than calcium carbonate. Treadwell and Reuter[2] found that 1 liter of water will hold 0.385 gram calcium bicarbonate in solution, while it will contain 1.954 grams of magnesium bicarbonate, besides 0.715 gram neutral magnesium carbonate.

When it is further remembered that magnesia is more movable in plants than lime, and that therefore one and the same molecule of magnesia can serve repeatedly as a carrier of phosphoric acid for the formation of nucleo-proteids and lecithin, it will not appear strange that a soil can still produce certain crops when the content of magnesia is very much smaller than that of the lime. This is especially true when such plants are grown as are capable of excluding any absorbed excess of lime from further physiological influence by transforming it into the nearly insoluble calcium oxalate. The situation is far different, however, on a soil that contains a considerable excess of magnesia over lime, and here a proper correction is an absolute necessity.

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[1] Compare also the interesting results of Thoms. Agric. Centralbl., 1898, p. 155, whose theoretical inferences from soil analyses were in full accord with the practical observation on the fertility of various domains.

[2] Zeitschr. f. Anorg. Chem., 1898, Vol. XVII, p. 170.

THEORETICAL DISCUSSION OF THE FUNCTIONS OF LIME AND MAGNESIA.

The physiological rôle of lime and magnesia was fully discussed in a previous bulletin,[1] hence a few lines touching the chief points will suffice here. The lime is, according to the theory of the writer, necessary for the formation of certain calcium compounds of nucleo-proteids required in the organized structures of nuclei and chlorophyll bodies, while the magnesia serves for the assimilation of phosphoric acid, since magnesium phosphate can give up its phosphoric acid more easily than any other phosphate that occurs in plant juices. While calcium is fixed in the organized structure, magnesium is movable, since it serves mainly in the form of secondary phosphate as carrier of assimilable phosphoric acid, which rôle can be repeated various times.

It follows from this theory that, in the case of an excess of lime being taken up, the assimilation of phosphoric acid will be rendered more difficult, since this acid will chiefly combine with the lime, and the chances for the formation of magnesium phosphate will thus be diminished. The effect will be the same as if the amount of available phosphoric acid in the soil were lessened—that is, the growth of the plant will be retarded and even starvation phenomena may set in. Many plants avoid this evil effect of an excess of lime in the juices by the precipitation of a part of the lime as oxalate, as mentioned above, while others[2] secrete it as carbonate, contained also in cystoliths.

If, on the other hand, magnesia is taken up in considerable excess over lime a poisonous action is observed. Plants succumb soon when placed in diluted solution of magnesium salts and no other, but calcium salts can prevent this effect. In fact, magnesium salts can exercise their nutritive functions only in presence of a sufficient amount of calcium salts. The plants can not, as with lime, turn an excess of magnesia into an insoluble form and thus render it innocuous. Only in certain cases may the formation of globoids or of insoluble magnesium protein compounds come into consideration.

The injurious action of magnesium salts has been previously explained by the writer,[3] as follows: The calcium nucleo-proteids of the organized structures are transformed by the presence of soluble magnesium salts into magnesium compounds, while the calcium of the former enters into combination with the acid of the magnesium salt. By the transformation of the organized calcium nucleo-proteids into magnesium nucleo-proteids the capacity for imbibition will change, which must lead to a disturbance in the structure which will prove fatal. Only the simultaneous presence of dissolved lime salts can prevent this effect, according to the law of mass. The writer noted, for example, among other observations, that certain algæ, such as Spirogyra, died in five days in a solution of 1 per 1,000 magnesium nitrate, while they remained alive for a number of weeks in this solution when 0.3 per 1,000 calcium nitrate was added. Of course, magnesium in form of carbonate or phosphate in the soil would act injuriously in much less degree than the soluble magnesium nitrate, or sulphate; but nevertheless injury will show in time.

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[1] Bul. No. 18, the physiological rôle of mineral nutrients, U. S. Dept. Agr., Div. Veg. Phys. and Path., pp. 28, 37, 42, 47, and 60.

[2] Saxifragineæ, Plumbagineæ, and some ferns secrete calcium carbonate on their epidermis.

[3] Bul. No. 18., U. S. Dept. Agr., Div. Veg. Phys. and Path.

How much, however, the result is influenced by the degree of fineness of these compounds may be judged from the observation of Ulbricht[1] that a large amount of the commercial precipitated basic magnesium carbonate acts much more injuriously than finely powdered magnesite, and that slaked lime in excess diminished the yield in lupin more than an excess of powdered marl. This author also described cases in which a rich manuring with lime depressed the yield, and further observed that a proper liming will remedy the evil effect of magnesium chlorid.

Also Atterberg (1892) observed injurious effects of large applications of magnesia upon oats on marsh soil and the prevention of this injury by liming. But previous to these authors E. Wolff[2] had observed on the one hand an injurious effect of burnt magnesia, and on the other the depression of the yield by a too excessive liming.

Heinrich observed a decrease of the crop of the yellow lupin of 36 per cent after adding as much as 0.5 per cent gypsum to the soil (quoted by Ulbricht, l. c.) and Ulbricht observed by adding only 0.011 per cent gypsum, a gain of 10.6 per cent of the lupin crop, and 21.5 per cent of the buckwheat crop, while with red clover and with timothy a gain of only 1.5 per cent was noted.

The crop of the yellow lupin was further considerably decreased in the experiments of Ulbricht by the application of 500 and 1,000 kilograms of lime to the morgen (1.6 acres). Also burnt magnesian limestone with 40 per cent magnesia had an injurious effect not only for lupin but for barley and vetch when applied in the amount of 500 kilograms to the morgen. A diminution of the lime one-half and of magnesia one-fourth, or an appropriate mixture of pure limestone with magnesian limestone, might have resulted in a favorable harvest. Lime and magnesia can exert their indispensable nutritive functions only in a certain dependence upon each other. Hence a certain ratio between these two nutrients will produce the most favorable results,[3] while a great excess of the one in the finest portion of the soil will lead to starvation and of the other to poisonous phenomena.

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[1] Landw. Vers. Stat., Vol. LII, p. 383 (1899). The basic properties of precipitated magnesium carbonate and of slaked lime are soon destroyed by the carbonic acid dissolved in the water of the soil.

[2] Grundlagen des Ackerbaues, 2d ed., p. 598.

[3] This ratio will differ somewhat with different crops.

THE RATIO BETWEEN LIME AND MAGNESIA IN SOILS OF DIFFERENT COUNTRIES.

Although soil analyses made in the old way do not permit of distinguishing between those compounds in the soils that are present in a very easily assimilable condition and those that are not so easily available, nevertheless a short review of the composition of soils of various countries might be made, since it will show at least what extremes of the lime and magnesia content might eventually, in case of fine distribution, be encountered by the roots. May it be distinctly understood, however, that it is beyond the scope of this bulletin to consider all the literature on soil analyses. This would have an essential value only if all the analyses were made in the manner indicated below.

SOILS OF AMERICA.

Soils of Alabama.—Bulletin No. 5, of the Agricultural Experiment Station at Auburn, Ala., gives analyses of soils and subsoils of eight different counties of that State. In three of these soils and four of the subsoils the content of magnesia exceeds that of lime:

	Per cent.
Maximum of lime	3.742
Maximum of magnesia	.671
Minimum of lime	.031
Minimum of magnesia	.005

Soils of Louisiana.—A report published by the Louisiana State University on geology and agriculture, Baton Rouge, La., 1893, contains in the first part ten analyses of soils of northern Louisiana, from five different districts. These soils are poor, but yield fair returns when judiciously manured. From these analyses, it is seen that the soils are mostly poor in lime and magnesia. In five cases the content of magnesia exceeds that of lime:

	Per cent.
Maximum of lime	0.145
Maximum of magnesia	.180
Minimum of lime	.009
Minimum of magnesia	.011

In Part II of that report forty-five analyses of soils and subsoils from different formations and districts are communicated. In sixteen cases magnesia predominates over lime, but this excess is small in eleven of them. Omitting the rich calcareous soils, Nos. 22 and 23, there is found:

	Per cent.
Maximum of lime	2.580
Maximum of magnesia	2.140
Minimum of lime	.033
Minimum of magnesia	.023

In most of the very fertile *alluvial* soils of Louisiana the amounts of lime and magnesia are nearly equal, and only in three cases out of twelve (subsoils included) is there an undue preponderance of magnesia.

Soils of various States and sections.—As to Florida, North Carolina, South Carolina, and Georgia, and some States of the arid regions, a review on the composition of soils by Hilgard[1] was consulted, and the average ratio of lime to magnesia calculated from these data, as follows:

Ratio of lime to magnesia in certain soils.

States.	Ratio of lime to magnesia.	Range of percentage.
Florida	1:0.30	0.07 to 0.14 per cent lime. 0.02 to 0.15 per cent magnesia.
North Carolina	1:0.91	
South Carolina	1:1.09	
Georgia	1:1.30	
California	1:1.38	1 to 2 per cent lime. 1 to 1.5 per cent magnesia.
Washington	1:0.85	
Montana	1:0.60	
Wyoming	1:0.54	

The soils of the arid regions of the four last-named States contain much more lime and magnesia and also more potassa and soda than the soils of the four first-named States of the humid regions, while the differences in the contents of phosphoric acid, sulphuric acid, and ferric oxide are not so marked. It must be pointed out, further, that Hilgard omitted intentionally all typical calcareous or limestone soils from consideration.

A comparatively small number of soils of Arizona, Utah, New Mexico, and Colorado have thus far been analyzed, but in most of these cases lime preponderates over magnesia. In Bulletin No. 33 of the Colorado Agricultural Experiment Station are mentioned five analyses of soils of which two show more magnesia than lime, and in Bulletin No. 9, of the same station, are mentioned analyses of soils from seven different localities, of which only one shows more magnesia than lime. The excess of magnesia over lime in these three cases is but small. In the last mentioned seven analyses the maximum of lime is 3.69 per cent, of magnesia 1.61; the minimum of lime is 0.68, of magnesia 0.54 per cent.

Of Utah soils, six samples were analyzed from Sanpete County[2] which show from 8 to 22 per cent of lime and only 0.13 to 1.8 per cent of magnesia. Of seven specimens of soils from Clarke County, none contained more magnesia than lime, the maximum of lime being

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[1] A report on the relation of soil to climate, by E. W. Hilgard, U. S. Dept. of Agr., Weather Bureau Bul. No. 3, Washington, 1892.

[2] Agr. Exp. Station Bul. No. 52, Logan, Utah. As to Arizona soils, some analyses are contained in Bul. No. 28 of the Agr. Exp. Station of Arizona.

2.75 per cent, of magnesia 1.71 per cent; the minimum of lime 0.87 per cent, of magnesia 0.52 per cent.

Recent analyses of soils of Oregon[1] show a prevalence of magnesia over lime in certain districts; in one sample from Washington County even 0.90 per cent of magnesia for only 0.13 per cent of lime was found.

Some analyses of soils of Nevada show a considerable excess of lime over magnesia.[2] This seems to be true also in Wyoming.[3]

Soils from British Columbia.[4]—Of thirteen samples analyzed, only four contained more magnesia than lime. The minimum of lime was 0.73 per cent, of magnesia 0.32 per cent; the maxima, 1.86 and 1.55 per cent, respectively. The ratio of lime to magnesia varies from 1:0.5 to 1:1.1.

Soils of Texas.—The analyses of twenty-two soils from Texas[5] show generally a considerable preponderance of lime over magnesia. This is also the case in Michigan.[6] Of twenty-nine different soils analyzed, not one contained more magnesia than lime, but the percentage of each of these oxides amounts in many cases to less than 1 per cent.

Soils of Minnesota and North Dakota.—In Minnesota and North Dakota lime predominates in the majority of cases over magnesia, to judge from the analyses made thus far. Only in the southeastern part of Minnesota magnesia predominates in most cases over lime. Snyder[7] mentions as an average of two hundred Minnesota soils a lime content of 2.16 per cent and an average magnesia content of 0.55 per cent; hence the amount of lime is about four times as large as that of magnesia. In certain cases, however, the magnesia content exceeded the lime content by one-half. The minimum lime observed was 0.16 per cent, that of magnesia 0.10 per cent.

As to North Dakota, there exist soils exceedingly rich in lime in the valleys of the Cheyenne, of the Red River, and of the Mouse River. In these cases the magnesia content remains below 2 per cent, while the lime content amounts from 18 to 23 per cent.[8] A case with a relatively large excess of magnesia over lime was observed in the James River Valley, namely, 0.14 per cent of lime for 1.38 per cent of magnesia; hence the amount of magnesia exceeded that of lime nearly tenfold. Of thirty cases in all, the magnesia exceeded the lime only in eight.

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[1] Oregon Agr. Exp. Station Bul. No. 20.

[2] Nevada Agr. Exp. Station Bul. No. 19.

[3] Wyoming Agr. Exp. Station Bul. No. 6.

[4] Experimental Farms Report, 1895, p. 200. These soils were never manured except incidentally by the droppings of animals when in pasture.

[5] Texas Agr. Exp. Station Bul. No. 25.

[6] Michigan Agr. Exp. Station Bul. No. 99.

[7] Minnesota Agr. Exp. Sta. Bul. No. 41, p. 32.

[8] Analyses of A. F. Ladd, North Dakota Agr. Exp. Sta. Bul. No. 22.

Soils of Tennessee.—The Agricultural Experiment Station Bulletin. Vol. X, No. 3, Knoxville, Tenn., 1897, contains the mechanical and chemical analyses of fifteen soils and eleven subsoils. In fully twenty-one of these twenty-six soil analyses, the magnesia content is larger than that of lime. This excess is in some cases but small, but in some unduly large. Thus, the sandstone soil of Grundy County shows 0.073 per cent of lime and 0.291 per cent of magnesia, or nearly four times as much magnesia as lime. Very correctly the reporting chemist, Charles F. Vanderford, remarks, on page 38, that "it is certain that dolomite (magnesian limestone) soils are much more easily injured by working when too wet than the soils in which magnesia is less prominently a constituent; and it is also a fact that dolomite soils readily and happily respond to an application of lime from a high-grade calcium carbonate." The soils of Arkansas show partially the same characteristics as those of Tennessee, but further information regarding them is desirable.

Soils of Rhode Island.—The Agricultural Experiment Station Bulletin No. 72, Kingston, R. I., contains seven analyses of the soils of that State, but only one of these soils shows an excess (a moderate one) of magnesia over lime:

	Per cent.
Maximum of lime	1.295
Maximum of magnesia	1.441
Minimum of lime	0.252
Minimum of magnesia	0.209

Bulletin No. 68 and the Seventh Annual Report of the Rhode Island Experiment Station contain two analyses showing a preponderance of lime over magnesia.[1]

Soils from South America.—The writer's search for a number of soil analyses of South America was not crowned with much success. It may, however, be mentioned that two samples of very fertile soils of Paraguay[2] showed an excess of lime over magnesia: Lime, 0.138 and 0.355 per cent; magnesia, 0.036 and 0.065 per cent.

SOILS FROM EUROPEAN COUNTRIES.

Soils from Russia.—The analyses of ten samples of the "Black earth,"[3] celebrated for its high degree of fertility, show from 0.66 to 2.16 per cent of lime and from 0.23 to 1.39 per cent of magnesia, and in not a single instance more magnesia than lime. The amount of phosphoric acid runs from 0.09 to 1.66 per cent, that of potassa from

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[1] Soils of Bermuda are generally rich in lime, one sample of which contains as much as 51.4 per cent lime for only 0.756 per cent magnesia.

[2] Jahresber. f. Agr. Chem., 1873.

[3] Ibid., 1873.

0.13 to 1.44 per cent. Very probably the mechanical condition of these soils is also very favorable.

Soils from Italy.—The analyses of soils from Italy, in the literature available to the writer, show a general preponderance of lime over magnesia.[1] Some of these are limestone soils, containing from 11 to 19 per cent of lime. One of them shows only 0.09 per cent of magnesia for 11.04 per cent of lime, or a proportion of lime to magnesia of 1:0.008. In most of the soils analyzed the amount of magnesia is less than one-half of that of lime.

Soils from Germany.—The analyses made of German soils relate in the majority of cases to lands manured for centuries. Liming is also an operation extensively practiced there. Nevertheless, there occur large districts that require liming, as in the northern part of the Odenwald.[2] Of thirty-seven samples of soils of this district, however, only two were found to contain more magnesia than lime, and this excess was moderate. The alluvium of the Rhine frequently contains more magnesia than lime. Thus Wohltman[3] has analyzed, for purposes of valuation, soils belonging to seven different degrees of fertility. Of these, only the first-class soil showed, besides a larger proportion of potassa and phosphoric acid, more lime than magnesia, while the soils from the second to the seventh class contained from one and one-fourth to eight times more magnesia than lime. On the other hand the Rhine deposit at Langenau (Hessia) contains eight times more lime than magnesia, as seen from the analysis of E. Schulze, 1873.

Many soils of the province of Brandenburg are very poor in lime (Ulbricht). An excess of magnesia over lime exists in the Berleburg district in Westfalen,[4] while in other parts of that province lime predominates over magnesia. On the other hand, in thirty samples of humus soils of Hanover and neighboring districts lime predominates over magnesia.[5]

	Per cent.
Maximum of lime	3.93
Maximum of magnesia	.39
Minimum of lime	.01
Minimum of magnesia	.01

The limestone soils of the best wine-producing districts are often very rich in lime, not only in western Germany but also at the mouth of the Rhone.[1] In the eleven vineyard soils analyzed by A. Hilger[2] calcium carbonate was found from 3.1 to 69.6 per cent, and magnesium carbonate from 0.9 to 5.1 per cent. In not a single instance did the amount of magnesia exceed that of lime.

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[1] These soils serve to a great extent for the culture of tobacco. Cf. work of N. Sparano; Guida Agrario-Merceologica, Rome, 1899.

[2] Lüdecke, Jahresbericht f. Agriculturchemie, 1898.

[3] Centralbl. f. Agriculturchemie, 1897.

[4] Jahresber. f. Agriculturchemie, 1873. Also in certain Bohemian districts magnesia predominates over lime. Ibid., 1875 and 1876.

[5] Analysis by Alberti, ibid., 1873 and 1874.

A great number of soils have been analyzed in Germany, but many of the publications are not available to the writer. It may, however, be mentioned that in even some recent German publications on the composition of certain soils and their need of manure, so little attention was paid to the amount of magnesia that this was not even quantitatively determined, while potassa, lime, and phosphoric acid were.

Soils from Hungary.—Bela von Bittó[3] determined the lime and magnesia in soil and subsoil from forty-three localities in Hungary, and of the eighty-four analyses mentioned, there are only seventeen showing an excess of magnesia over lime. Comparing all those analyses there is found:

	Per cent.
Maximum of lime	25.44
Maximum of magnesia	3.81
Minimum of lime	.14
Minimum of magnesia	.08

The range of proportion between the amounts of lime and magnesia is 1:0.02 to 1:3. In most cases of the excess of magnesia over lime, however, this excess is but small and does not amount to more than one-half. These soils have been manured for years, either with animal dung or with commercial fertilizers; hence, often considerable differences of composition occur in the same formation between surface soil and subsoil, especially in the relation of the lime and magnesia content.

From the observations of the above author it follows that the greatest yield was obtained on those soils in which the amount of magnesia either was smaller than that of lime or exceeded the latter only very moderately. It is to be regretted, however, that the mechanical condition and the amount of the other nutrients were not investigated, thereby permitting more reliable inferences.

From the analyses of Hungarian soils by Tolles[4] it is seen that either the lime predominates over magnesia or if magnesia is in excess, it is but moderate, not reaching one and one-half times that of lime.

SOILS FROM ASIATIC COUNTRIES.

Soils from Japan.—A great number of soils have been analyzed in the laboratory of the geological survey of Japan, and very valuable reports have been issued on that subject by the Imperial Japanese

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[1] Analysis by Alberti, Jahresber. f. Agriculturchemie, 1873 and 1874.

[2] Ibid., 1879 and 1886.

[3] Landw. Vers.-Stat., Vol. L, p. 245.

[4] Ibid., Vol. XLII, p. 409, 1893.

Government. Some typical soils show the following percentages of lime and magnesia:

Percentages of lime and magnesia in some typical soils of Japan.

Soils.	Per cent of lime.	Per cent of magnesia.
Clay soil—I	0.96	0.87
Clay soil—II	0.99	2.12
Gneiss loam	0.39	0.04
Trachyte loam	0.1-1.0	0.1-1.3
Andesite lava	1.7-4.0	1.2-3.0
Diabas soil	0.90	1.87
Basalt tufa	2.21	1.38

The last-mentioned soil is described as an excellent one. While in this case the ratio of lime to magnesia is as 1:0.6, there occur soils which contain more than double as much magnesia as lime.

Soils from India.—The soils from the Indo-Gangetic alluvium[1] are almost without any pebbles. One of the most fertile soils shows the proportion of 0.47 per cent lime to 0.32 per cent magnesia, or 1:0.67. The highest percentage of lime (limestone soils excluded) was found to be 2.07 per cent, and of magnesia 1.97 per cent. The ratio of lime to magnesia varies from 1:0.56 to 1:2.35 among the eleven samples analyzed.

In the brown alluvial soils from Madras lime occurs partly as carbonate and partly as hydrous silicate. The amount of lime varied in ten samples from 0.05 to 1.23 per cent, and that of magnesia from 0.20 to 1.87 per cent, and the ratio of lime to magnesia from 1:1.52 to 1:1.42. It was not stated whether these loams and sandy soils contained the magnesia only as carbonate or partially as silicate; neither is mention made about fertility and the principal crops raised. Of seven samples of red soils from Madras, only one contained more lime than magnesia, and in one of them the amount of magnesia (1.1 per cent) exceeded that of lime (0.1 per cent) eleven times.

In eighteen samples of the black cotton soils of Regur the amount of lime varied from 1.16 to 5.35 per cent, that of magnesia from 1.79 to 3.09 per cent, and the proportion of lime to magnesia from 1:005 to 1:2. In the twelve samples of laterite soils analyzed the amount of lime varied from 0.14 to 1.5 per cent, that of magnesia from 0.2 to 0.81 per cent, and the ratio of lime to magnesia from 1:0.4 to 1:2.

In five samples of manured coffee soils the amount of lime varied from 0.3 to 0.44 per cent, that of magnesia from 0.38 to 0.66 per cent, and the ratio of lime to magnesia from 1:1.2 to 1:1.5. In eleven samples of tea soils the amount of lime varied from 0.03 to 0.25 per cent, that of magnesia from 0.08 to 1.08 per cent.

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[1] Analyses from T. W. Leather, in the Calcutta Agricultural Ledger, 1898, No. 2.

Recently four analyses of soils of southern India were published by C. Massey,[1] which show a considerable preponderance of lime over magnesia in that part of the country: Lime, 0.836, 0.993, 0.825, and 0.999 per cent; magnesia, 0.210, 0.300, 0.255, and 0.352 per cent. It may be mentioned further that tobacco soils of Sumatra and Java, when extracted with acetic acid (diluted 1:5), yield more than twice as much lime as magnesia, according to Van Bemmelen's analysis (1890). Again, soils of Asia Minor used near Smyrna and Erbeiti for the culture of figs contains more lime than magnesia.[2]

SOILS FROM AFRICAN COUNTRIES.

Analyses were recently published of soils of Cameroon, Senegambia, and German East Africa.[3] In the five samples of Cameroon soils, as well as in the three samples of Senegambian soils, there is noticed a great deficiency of lime. The amount present ranges from 0.026 to to 0.174 per cent. Further, there is a considerable excess of magnesia over lime, amounting even to eleven fold and more. These soils would doubtless be much benefited by liming.

Among the seventeen samples of soils from German East Africa there are not less than thirteen in which lime predominates over magnesia. Maximum of lime, 0.893 per cent; of magnesia, 0.530 per cent.

Also eight samples of soils from different parts of the Congo State were analyzed,[4] four of these showing an excess of magnesia over lime.

SOILS FROM AUSTRALIA.

Of analyses of Australian soils, two only, made by Mr. F. B. Guthrie,[5] are available. These soils were taken from the same field and were of a light sandy loam. While the crop (barley) was of good growth on one, it showed bare and stunted spots on the other. The mechanical analyses and the amounts of potash, phosphoric acid, and nitrogen in the two soils were very similar. The only difference of any moment shown by the analyses was in the content of lime. In the good soil it was 0.065 per cent; in the inferior, 0.015 per cent. The analyst recommends liming the inferior soil. Unfortunately, the magnesia was not determined, as it would probably throw more light on the causes of the inequalities in the two soils.

RIVER DEPOSITS.

It may, in addition, be mentioned that such river deposits as are highly esteemed for their fertilizing properties contain more lime than magnesia. The quantities of potassa and phosphoric acid present in these sediments is by no means large, that of the former varying from 0.10 per cent (Colorado) to 0.28 per cent (Rio Grande), that of the latter from 0.092 per cent (Rio Grande) to 0.27 per cent (Colorado, near Fort Yuma, Ariz.). The amount of lime and magnesia in some of these sediments was found as follows:

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[1] Chemical News, 1895, Vol. LXXI, p. 261.

[2] Cal. Agr. Exp. Stat. Bul. No. 101.

[3] Jahresber. f. Agriculturchemie, p. 49, 1897.

[4] Ibid., 1896.

[5] Agr. Gaz. New South Wales, 10, 1899, No. 2, p. 166.

Amount of lime and magnesia in some river sediments.

Rivers.	Per cent of lime.	Per cent of magnesia.
Nile, Egypt[1]	1.725	0.046
Rio Grande, New Mexico[2]	4.384	0.080
Colorado River, Nevada, near Cottonwood Island[2]	7.000	0.690

[1] Knop (1873) mentions, in his analyses from two different localities on the Nile, calcium carbonate, 3.30 and 4 per cent, and magnesium carbonate, 0.78 and 0.28 per cent. The analysis in the table relates to another locality.

[2] Annual report of the U. S. Geographical Surveys west of the 100th Meridian, Capt. George M. Wheeler in charge, Washington, 1875. The sediment of the Colorado River from the vicinity of Fort Yuma, Ariz., was analyzed in the Agr. Exp. Sta. of Arizona, Bul. No. 6.

Sediments in western Switzerland claimed to be very fertile, deposited by the Morges, the Sionne, and the Borgne, show lime, 2.34, 21.70, and 22.82 per cent; magnesia, 1.16, 1.25, and 1.12 per cent.

It will be seen from the above review—

(1) That the ratio of lime to magnesia ranges between wide limits.

(2) That in the majority of cases lime predominates over magnesia.

(3) That in all the instances of great fertility the soil never shows any marked excess of magnesia over lime, but, on the contrary, generally more lime than magnesia.

In many of the above-cited instances, however, safe agricultural conclusions can not be drawn, since the mode of analysis (treatment with hydrochloric acid) does not admit of distinguishing between easily and difficultly available mineral nutrients.

SOME SPECIAL PHYSIOLOGICAL CASES RELATING TO THE RATIO BETWEEN LIME AND MAGNESIA.

Some physiological instances may now be considered which relate to the ratio between lime and magnesia.

Knop[1] infers from his investigations with barley that two molecules of calcium nitrate should be present in the culture solution for one molecule of magnesium sulphate, which would correspond nearly to the proportion of 1 part of lime to 0.5 of magnesia. E. Wolff calculates, however, for the minima of lime and magnesia required for the production of the dry matter of the oat plant 0.25 per cent lime and 0.20 per cent magnesia, or a ratio 1:0.8.

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[1] Centralbl. f. Agriculturchemie, 1861, pp. 465, 564, and 945.

In experiments with maize, Knop found that the lime requirement of this plant is relatively larger than that of barley. From the data given the suitable proportion of lime to magnesia would be 1:0.25. Stohmann differs, however, on this point, and applies the ratio of lime to magnesia as 1:0.6.

As to the tobacco plant, cultivated for its abundant foliage and topped to prevent seed production, it is natural to suppose that it requires more lime in proportion to magnesia than the cereals generally do. The percentage amounts of lime and magnesia from a number of ash analyses of tobacco leaf may here be mentioned. In 100 parts of ash are contained:

Percentage of lime and magnesia in ash of tobacco leaf.

Leaf.	Per cent of lime.	Per cent of magnesia.
Virginia tobacco[1]	31.12	8.58
Virginia tobacco	47.27	10.16
Virginia tobacco	32.56	14.69
Virginia tobacco	37.36	6.37
Kentucky tobacco	35.35	9.35
Hungarian tobacco[2]	27.1 to 60.3	6.1 to 24.8
German tobacco	39.53	9.61

[1] Kissling, der Tabak, p. 41.

[2] Botan. Jahresber., 1881.

It will be seen from these few data that while the amounts of lime and magnesia show a wide range there is always a considerable excess of the former over the latter. It might not be far from the truth to assume that the average lime content of the tobacco leaf is about four times that of magnesia. This would agree fairly well with the ratio shown by the analyses of H. Smith of Massachusetts tobaccos. The soils, however, should contain still more than four times the amount of lime compared with that of magnesia.

Comparing that ratio with that found in the tobacco soils considerable discrepancies are observed. From analyses of tobacco soils published by William Frear[1] the following data relative to the lime and magnesia content may be quoted:

Percentage of lime and magnesia content of certain tobacco soils.

Element.	Lancaster, Pa.		New Milford, Conn.	Granville County, N. C.	Sumatra.
	I.	II.	III.	IV.	V.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lime	0.61	0.41	0.32	0.07	0.77
Magnesia	1.26	2.05	0.78	0.02	0.37

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[1] The soil of Lancaster County limestone belt in its relation to tobacco culture, Penn. State College Ann. Rept., 1894, p. 160.

The lime content of these soils is not only very low when the high lime requirement of the tobacco leaf is considered, but in the first three cases of the five mentioned the soils contain less lime than magnesia. Lime would prove of great benefit here, avoiding, however, magnesian limestone. On soil IV, however, magnesian limestone may be successfully applied.

Tobacco soils in general must possess not only a proper chemical composition, but also a very satisfactory mechanical condition.[1]

The rapid growth and the relatively large leaf surface make tobacco more susceptible to the mechanical condition of the soil than most crops, since the roots require conditions for a rapid spreading. It would be of considerable interest in this regard to make a comparative investigation of the soils of Vuelta Abajo and Vuelta Ariba in Cuba. The two valleys are not separated by a great distance, but the former produces a tobacco far superior to that of the latter.

That certain chemical qualities of tobacco are dependent upon a certain ratio of lime to magnesia seems to receive an illustration from the fact that in Italy the soils for raising tobacco are exceedingly rich in lime and sometimes very poor in magnesia. There it was observed that tobacco called Spagnuolo develops better odor (but not always a better aroma in smoking) when the amount of magnesia was increased by irrigating with water containing magnesium salts.[2] This is also asserted for the Shiras tobacco from Persia.[3]

The grape also requires a considerable amount of lime, exceeding very much that of magnesia, as seen from the following data taken from Wolff's Tables:[4]

Percentages of lime and magnesia required by the grape.

Parts of vine, etc.	Lime in the ash.	Magnesia in the ash.	Total ash in dry matter.
	Per cent.	*Per cent.*	*Per cent.*
Foliage (in August)[1]	25.69	10.30	1.45
Wood (in February)[1]	30.41	7.19	1.27
Wine (Riesling)[1]	7.43	0.67	0.28
Upper wood	40.17	6.17	2.91
Lower wood	37.92	8.24	2.70
Upper leaves	48.17	7.35	6.96
Lower leaves	50.89	7.00	8.47

[1] The soil from which these samples were derived contained 0.018 per cent of lime and 0.002 per cent of magnesia, both soluble in cold concentrated hydrochloric acid.

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[1] Compare especially the publications of Milton Whitney on tobacco soils, Bul. No. 4, Weather Bureau, and No. 11, Division of Soils, U. S. Dept. Agr. The above remarks are made for the condition that the lime and magnesia content are equally well assimilable in these soils.

[2] Sparano, Guida Agrario-Meteorologica, Roma, 1899.

[3] Kew Garden Bulletin, 1895.

[4] Aschen-Analysen, II, Berlin, 1880.

For one hectare of vineyard there would be annually required 45.48 kilograms of lime and 16.92 kilograms of magnesia, or nearly two and two-thirds times as much lime as magnesia.[1] It happens, however, that in the soils of the vineyards often a very different ratio prevails, and especially that their lime content runs very high. It was observed in France that soils too rich in lime (18 per cent and over) produced the "yellows" in the vines, and that spraying the leaves with a diluted (1 per cent) solution of ferrous sulphate cured the disease.[2] The high content of calcium carbonate of the soil probably neutralized the acid secretions of the roots, and thus frustrated the absorption of the iron compounds from the soil. Neither magnesium nor ammonium sulphate were observed to have any curative effect in these cases.[3] The question whether a great excess of lime can under other conditions interfere with the absorption of the iron deserves further attention.

Another cause of the "yellows" appears to be sometimes a lack of lime in the soil, since in certain districts of France, les Pouilles and l'Aude, slacked lime has been applied for the last fifty years to the affected foilage with much success, as Meunier, Cachard, and Gos report.[4]

Further causes of the "yellows" may be a lack of magnesia or of phosphoric acid or of nitrogen. Stohman[5] mentions that plants cultivated for some time without any supply of nitrogen compounds lose the normal green of the leaves, and that a supply of ammonium nitrate will remedy the evil. Knop[6] observed that an excess of calcium nitrate, as well as of magnesium nitrate, in culture solutions, can cause yellowing of the leaves, and that in such cases an addition of ammonium sulphate had a curative effect. Stohman, however, does not fully agree, since he was unable to cure such cases by ammonium nitrate.

The writer showed years ago that a kind of "yellows" is produced by a lack of phosphate.[7] Algæ turned gradually yellow in culture solutions in which phosphoric acid was absent, and the addition of a trace of secondary sodium phosphate sufficed to restore the normal green color.

In regard to the dependence of full development upon the ratio of lime and magnesia, an interesting observation on the chestnut tree may be mentioned. Grandeau and Fliche[8] analyzed leaves and branches of a tree in normal healthy development and of another of poor and meager development. From the figures given a considerable difference in the content of potash, lime, and magnesia will be noticed. Lime is increased in the latter case, while magnesia and potash are diminished.

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[1] Wolff's Tables, II, p. 63.

[2] Jahrbuch der Deutschen Landw. Gesellschaft, Vol. VIII, p. 437.

[3] The French grape vines are much more susceptible to the "yellows" after being grafted with the American vine than they are before, as Ladecke mentions. The varieties Jaques and Riparia appear to be unable to thrive on soil with more than 18 per cent of lime, but Rupestric is capable of it.

[4] Le Progrès Agricole et Viticole, 1899, No. 31.

[5] Chem. Centralbl., 1861, p. 597.

[6] Ibid., p. 476.

[7] Botan. Centralbl., 1891, p. 371.

[8] Wolff's Tables, II, p. 102.

Percentage of potash, lime, magnesia, etc., in leaves and branches of chestnut tree.

Parts of tree.	Total ash.	In 100 parts of ash.			
		Potash.	Lime.	Magnesia.	Phosphoric acid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Normal leaves	4.8	21.67	45.37	6.63	12.32
Poorly developed leaves	7.8	5.76	74.55	3.70	12.50
Normal branches	4.74	11.65	73.26	3.99	4.53
Poorly developed branches	5.71	2.69	87.30	2.07	4.27

The amount of magnesia relative to lime is considerably smaller in the poorly developed leaves and branches than in the normal ones of the chestnut, as seen from the following figures:

	Magnesia to 100 parts lime.
Healthy leaves	14.8
Poorly developed leaves	4.9
Healthy branches	5.4
Poorly developed branches	2.3

A plant of special agricultural importance is the sugar beet. In comparing the lime and magnesia of this plant with that of others some data of interest are observed.[1] In 1,000 parts dry matter are contained:

Percentage of lime and magnesia to 1,000 parts dry matter in sugar beets and other plants.

I. GRASSES.

Content.	Per cent.	Plants, etc.
Minimum of magnesia	1.41	Young winter wheat (2).
Maximum of magnesia	6.50	Maize in flowering stage (7).
Minimum of lime	2.71	Winter wheat in flowering stage (7).
Maximum of lime	16.46	Rye grass (7).

II. CLOVER AND OTHER FODDER HERBS.

Minimum of magnesia	3.34	Seradella in the flowering stage (3).
Maximum of magnesia	10.90	Buckwheat, flowering (17).
Minimum of lime	10.52	Lupin hay (3).
Maximum of lime	38.61	Red clover, flowering (13).

III. LEAVES OF THE ROOT CROPS.

Minimum of magnesia	4.61	Leaves of turnips (10).
Maximum of magnesia	16.86	Leaves of sugar beet (25).
Minimum of lime	16.34	Leaves of the common beet (18).
Maximum of lime	44.52	Carrot (8).

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[1] Wolff's Tables, II.

Percentage of lime and magnesia to 1,000 parts dry matter in sugar beets, etc.—Continued.

IV. ROOT CROPS.

Minimum of magnesia	1.43	Topinambur (2).
Maximum of magnesia	8.26	Common beet (19).
Minimum of lime	1.00	Potato (59).
Maximum of lime	8.49	Turnips (13).

NOTE.—The numbers in parentheses indicate the numbers of analyses that served for calculation of the average. A few plants of subordinate interest were excluded from comparison.

It is seen from these data that among the leaves of the plants of the three groups here considered (comprising in Wolff's Tables seventy species from various families), the sugar beet leaves contain the highest amount of magnesia, and, further, that among the leaves of root crops the common beet contains the maximum of magnesia in the roots and the minimum of lime in the leaves. From Wolff's Tables, I (page 170), it can further be learned that of all the leaves there considered those of the common beet and the sugar beet show, in relation to the amount of lime present, the largest amount of magnesia.

Average lime and magnesia content to 1,000 parts dry matter in sugar and common beet leaves.

Plant.	Parts of lime.	Parts of magnesia.
Sugar beet leaves[1]	25.76	26.34
Common beet leaves[1]	16.84	14.44
Sugar beet leaves[2]	30.06	16.86
Common beet leaves[2]	16.34	14.62

[1] Wolff's Tables, I, p. 170.

[2] Wolff's Tables, II, p. 145.

It may be of some interest also to compare the ratio between lime and magnesia in leaves of various other plants. The following ratios were calculated from the average data given in Wolff's Tables:

Comparison of ratio of lime and magnesia in various plants.

Plant, etc.	Total ash in 1,000 parts dry matter.	Ratio of lime to magnesia.
	Per cent.	
Wheat, flowering	69.6	1:0.68
Clover, flowering	68.6	1:0.31
Alfalfa, flowering	73.8	1:0.12
Lupin	41.0	1:0.37
Potato plant	85.8	1:0.50
Turnip	116.4	1:0.12
Carrot[1]	55.8	1:0.10
Lettuce	180.3	1:0.44
Sugar cane	23.6	1:0.95
Sugar beet[2]	148.8	1:0.56
Sugar beet[1]	175.8	1:1.02
Common beet	153.4	1:0.90

[1] Wolff's Tables, I.

[2] Wolff's Tables, II.

The roots of the sugar beet contain only about one-fourth as much ash as the leaves, but relative to the lime more magnesia than the leaves.[1]

Lime and magnesia content to 1,000 parts of dry matter of root of sugar and common beet.

Plant.	Total ash.	Lime.	Magnesia.	Ratio of lime to magnesia.
	Per cent.	*Per cent.*	*Per cent.*	
Sugar beet[1]	38.3	2.33	3.01	1:1.3
Common beet	75.8	2.83	8.26	1:2.9

[1] Recent publications mention a smaller amount of magnesia.

The transformation of the common beet into the sugar beet seems to be connected with a small decrease of the magnesia content in the root and an increase of lime in the leaf. (See table above.)

It is further of considerable interest that *the seeds of the common beet and sugar beet are among those richest in magnesia.* From Wolff's Tables, II, p. 142, containing the averages of sixty-seven different seeds and fruits, it will be seen that for 1,000 parts of dry matter of seed the *magnesia* content was from 0.12 parts (horse chestnut) to 10.02 parts, *which maximum belongs to the seed of the common beet.* For 1,000 parts of the seeds of the *sugar beet the magnesia content amounts to 8.55 parts, which number is only surpassed by that for the almond (8.65 parts).* The lime content of those seeds is a moderate one, 8.83 and 11.89 parts, respectively, for 1,000 parts of dry matter, while the extremes are 0.15 (winter barley) and 33.05 (carrot).

The sugar beet belongs to those crops that are rich in mineral matter, since the ash varies from 14 to 20 per cent and over. It can, therefore, not create surprise to see beets still grow on soils which by a certain content of soluble salts interfere seriously with other crops, as grasses and legumes. Hilgard and Loughridge[2] made experiments on lands considerably impregnated with alkali salts in southern California, and inferred that sugar beets may even be raised on soils containing as much as 12,000 pounds of alkali salts per acre to the depth of 3 feet. These salts consisted of sulphates, nitrates, chlorides, and carbonates, but the chlorid content did not exceed 500 pounds per acre.

Champion and Pellet found that for the formation of 100 pounds of sugar in beets the whole plant must consume:

	Pounds.		Pounds.
Phosphoric acid	1 to 1.2	Lime	1.5 to 1.6
Potash	5 to 6.0	Magnesia	1.2 to 1.4
Soda	1.5 to 2.0	Nitrogen	2.7 to 3.5

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[1] Wolff's Tables, II.

[2] Report of the Cal. Expt. Sta., 1894 and 1895.

From all these considerations we can infer that for the culture of the sugar beet one of the many conditions of success is a magnesia content nearly equaling the lime content of the soil.

Numerous manuring experiments have been made, with more or less success, to ascertain the best development of the sugar beet to insure the maximum production of saccharose. Some attention should also be paid to the regulation of the ratio between lime and magnesia in the soil, as this may prove of great importance.

CORRECTION OF LIME AND MAGNESIA CONTENT IN SOILS.

Although there are crops which require a relatively large amount of magnesia when roots, tubers, and seeds are richer in magnesia than in lime, yet the entire plants of any crop require more lime than magnesia, since the stalks and leaves show a preponderance of lime; hence such soils would, other things being equal, be best adapted for agricultural purposes which show a preponderance of lime over magnesia, at least in the finer particles available to the plant roots. The amounts of lime and magnesia, in kilograms, extracted from one hectar (nearly 2.5 acres) of ground by various plants in one year[1] are in average as follows:

Lime and magnesia extracted from soil by various plants.

Plants, etc.	Lime.	Magnesia.
	Kilograms.	*Kilograms.*
Cereals	16	10
Tobacco	30	15
Potato	40	20
Common beet	40	27
Vine	46	17
Legumes	50	12
Pine forest	70	9

Since, however, the roots come into direct contact with only a relatively small portion of the soil, the absolute amount of available lime and magnesia must be very much greater than would follow from the data in the table.

The review of soils above given leaves no doubt that lime preponderates over magnesia in most soils, and that the very best soils show, among other advantages, this peculiarity. But, nevertheless, cases are not infrequent in which the amount of magnesia is larger than that of lime. As long as this excess is only moderate no evil effects may be noticed, but they become evident when this relative excess is considerable. A correction of the soil by liming for the physiological needs of the crops will then be in order. The nature of the crops and the depth to which the roots penetrate will serve as a basis for the extent of liming. An undesirable increase of magnesia is often caused by the manuring with crude potassium salts of Stassfurt, as above pointed out. In this case also liming furnishes the remedy.[1]

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[1] Ebermayer, Chemie der Pflanzen, Vol. I.

This correction grows in importance with the absolute amount of magnesia contained in the soils,[2] since the poisonous effect of magnesia grows with the concentration. It is therefore clear that the determination and balancing of the available amount of magnesia and lime in the soils is necessary for successful farming on apparently infertile soils. The amount, however, available for the next crop is not obtained by treating the entire soil with concentrated hydrochloric acid, since compounds are thereby dissolved which the roots can not utilize before their further disintegration or final distribution. The system of Dyer, consisting in the treatment of the soil with 1 per cent citric acid for seven days after "neutralization" of the carbonates, is apparently more in accord with the dissolving power of the roots, but Lemmermann[3] has shown for potassa that even 5 per cent hydrochloric acid does not extract all that is available for certain plants. This may hold good also for lime and magnesia whenever they are present, not as carbonates, but wholly or partially as hydrous silicates. Since Daikuhara[4] has observed for phosphoric acid that soils treated with acetic, citric, or oxalic acids in 1 per cent solution are only partially deprived of the phosphoric acid available for barley, it will be best to follow the system of Thoms—that is, to treat the soil with a hydrochloric acid of 10 per cent. However, with that modification only that portion of a soil that passes through a 0.5 cm. sieve is thus treated,[5] and the percentage in this fine sand, silt, and clay only is determined. It will be best to mix 200 grams of this fine portion in a 1-liter flask with 400 c. c. of the 10 per cent hydrochloric acid, and let the mixture stand, with frequent shaking, for one day at the ordinary temperature. Water is then added to fill up to 1 liter, and, after well mixing and filtering, certain portions of the filtrate serve for the determination of the available nutrients. The results are calculated for the whole soil. Thus, the easily available amounts of lime and magnesia will be at least approximately obtained. It will be impossible to obtain numbers that are constants of availability, since the roots of different species have also different powers of absorption. Nilsen and Eggertz[1] found that a very fertile soil became, after extraction with 2 per cent hydrochloric acid, sterile for barley, but not yet sterile for oats. A treatment of the soil with acid of double the strength was necessary to render it sterile for oats.

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[1] P. Wagner very correctly remarks (Jahresbericht für Agrikultur Chemie, 1897, p. 254): "The successful application of the crude Stassfurt salts containing chlorid and sulphate of magnesium presumes a soil rich in carbonate of calcium. More attention has to be paid to the magnesia content of the Stassfurt salts than has hitherto been the case. Under certain circumstances the magnesia content can act very favorably, while a too rich manuring with magnesia salts may prove injurious." This is exactly what follows from the writer's theory published five years previous to Wagner's utterances.

[2] The excess of magnesia over lime in soils never reaches such proportions as, on the other hand, the excess of lime over magnesia may do. Thus, there frequently exist soils with 20 per cent to 40 per cent of carbonate of lime, while soils with over 5 per cent of carbonate of magnesia are rarely found.

[3] Landw. Vers. Stat., Vol. XLIX, p. 33.

[4] Private communication.

[5] Still more correct results might be obtained by using a 0.2 cm. sieve, but this must be determined by further tests.

As regards the separation of the soil into a finer and coarser portion, it must be mentioned that experiments have proved that the finer particles come principally into consideration in regard to fertility. Larger particles may be attacked along their surface only, but will not be dissolved by one year's growth of vegetation.

Should the analyses not show, as above assumed, an excess of magnesia, but, on the contrary, an amount of available magnesia far below that of lime in the fine particles of the soil, an addition of finely ground unburned magnesite or unburned pulverized magnesian limestone should be made. The application of artificially precipitated basic magnesium carbonate or burned magnesia can not be recommended, since they are not only too expensive for the purposes of agriculture, but also very injurious, being easily absorbed, owing to their very fine pulverulent condition.

The above-mentioned experiments of Ulbricht furnish abundant proof of the considerable differences in the action of powdered magnesite and precipitated magnesium carbonate.

Finally, the analysis may show a lack of lime as well as of magnesia. Soils occur, indeed, with less than 0.1 per cent of these nutrients. Manuring with a mixture of marl and magnesite or with pulverized magnesian limestone containing less than 40 per cent magnesia is then in order.

If the ratio of lime and magnesia in the soils is judicially regulated, great benefit to agriculture will result and an essential step forward be made.

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[1] Landw. Vers. Stat., 1891, Vol. XXXVIII, p. 344.

II. EXPERIMENTAL STUDY OF THE RELATION OF LIME AND MAGNESIA TO PLANT GROWTH.

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INTRODUCTION.

The wide distribution of lime and magnesia in soils is very evident from the tables of analyses presented in the first part of this bulletin. The fact that these elements are in some degree present in all soils and able to supply the direct needs of plants has probably been the reason for the neglect of the extended study of their relations to each other.

THE RÔLE OF LIME IN THE SOIL.

The necessity of lime and magnesia in plant production is a fact that has long been recognized. The favorable influence of lime on certain soils has led to the very common agricultural practice of liming. The presence of lime may serve several purposes. It supplies this necessary element in the construction of plant tissue, hastens the decomposition of organic matter, facilitates the assimilation of other elements, and produces favorable physical conditions in the soil. It also causes an increased bacteriological and fungous growth in the soil, in some cases favorable to plants, as in reducing the club-root of the turnip and cabbage,[1] and sometimes unfavorable, as increasing the scab of potatoes.[2] Deherain mentions that agriculture in some sections of France has by the use of lime undergone an entire revolution.

Lime may then serve in plant production in several rôles, which may be denominated physical, chemical, and physiological. Physically, it may be of benefit when added to stiff, retentive clays, rendering them mellow, better drained, and more easily cultivated. Chemically, it will render available and within the ability of the plant to absorb certain necessary elements locked up in an insoluble combination. Physiologically, it has a necessary rôle to play in carrying on the functions of plant growth and the building up of cells. It is the latter rôle of the element in connection with magnesia that this paper deals.

THE RÔLE OF MAGNESIA IN THE SOIL.

Certain experiments as well as the percentage of magnesia found in plants, especially in the seeds, prove the necessity of this element in plant production. Besides being a necessary constituent of plants, it plays a physiological rôle, serving especially in aiding the assimilation of phosphoric acid, as already pointed out. It is not the province of this report to discuss at any length the physiological action of lime and magnesia. That subject is presented in detail in the first part of this bulletin, in which Dr. Loew, from the results of investigations, draws the conclusion that where magnesia is in excess, the lime, as the stronger base, will combine with the acid of the magnesium salt, while the magnesia will enter into the place which the lime had occupied in the organized structure. Again, if lime salts are in great excess the formation of magnesium phosphate, and consequently the assimilation of phosphoric acid will be retarded.

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[1] Campbell, Board Agr. Rpt., Great Britain, 1894–95.

[2] Wheeler, Rhode Island Rpt., 1896.

An excess of magnesia in soils may exert a poisonous action upon plants. This has been noticed in applying limestone containing a large percentage of magnesia. Again, the continued application of potassic fertilizers as kainit and carnallit containing magnesia has in some instances rendered the soil unfit for agricultural purposes. This is probably due to the raising of the magnesia content of the soil, as may be done by continued application of certain crude potash salts. A sample examined by the writer contained 9.37 per cent of magnesia. The difference in the lime and magnesia content may also be influenced in another way. Goessman reports[1] an increased loss of lime from soils to which muriate of potash was applied. The analysis of drainage water from such plats showed a large percentage of calcium chlorid.

Magnesia is found naturally in alkali soils of the arid districts and possibly in soils of the humid regions to such an extent as to render them barren of any vegetation. It is also highly probable that the magnesia content of a great many soils is excessive to such an extent as to hinder them in producing maximum crops.

THE OBJECT OF THE EXPERIMENTS.

The object of the work herein reported was to study the effect of varying amounts of calcium and magnesium salts on the growth of economic plants, and especially the ameliorating effects of lime salts in overcoming the noxious results of an excess of magnesia. It was also sought to determine the ratio between the two bases which best promote the early germination and quick development of plants. This might throw some light on the question of liming, as giving some indication of the amount of lime to be supplied, and in other cases pointing out the danger of adding an excessive amount of magnesia through applying certain limestone and potassic fertilizers containing that base. Another point sought to be brought out is the form in which lime best acts in counteracting the noxious effects of an excess of magnesia and also the testing of chemical nutrients other than lime in ameliorating such evil results.

The experiments described were begun in 1899, and cultures of the different plants in the various media were continued up to June, 1901. Not only does it take some time to get assured results in culture experiments, but owing to the various elements involved in many soils employed it is necessary to have accumulative evidence to warrant safe deductions. In making the experiments, water, sand, and soil cultures were employed and comparisons made of many trials in the different media used. In the sand and soil cultures the calcium and magnesium were incorporated as carbonates, sulphates, and nitrates. In water cultures the more soluble salts of nitrates and sulphates were employed. In comparing the two bases the molecular weights have been used for reasons readily apparent. If there is a ratio of effect between the two elements the molecular weight is the better basis of estimating it, but in agricultural practice the actual weight, as a matter of course, would be found the more practicable. However, as may be readily seen, one ratio may be quickly estimated from the other.

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[1] Mass. Hatch. Exp. Sta. Bulletin No. 38.

LIME AND MAGNESIA AS NITRATES AND SULPHATES IN WATER CULTURES.

The following series of water cultures were made in bottles holding 250 c. c., the stem of the plant being supported by a cotton plug in the mouth of the bottle. The bottles were placed in a box covered with sand to exclude light from the roots. The plant used was a variety of cowpea which had been sprouted in clean sawdust.

These experiments were preliminary and made not alone for the evidence shown by the results attained, but as a basis to guide in more extended trials. It was not attempted to bring the plants to maturity in the small amounts of culture media used, but to carry them beyond the point where a direct physiological result would appear from the addition of the various percentages of the lime and magnesia salts employed.

The following solutions of magnesium and calcium salts were made up with distilled water, and plants 5 cm. high were set July 17. The results are shown in the following table:

Results of experiments with cowpeas set July 17.

No. of bottle.	July 17.		July 20.	July 23.
	Solution.	Per cent.	Condition.	Condition.
1	Check		Healthy	Drooping.
2	MgO as $MgSO_4$	0.2	Dejected	Dead.
3	MgO as $Mg(NO_3)_2$	0.1	Leaves shriveled	Dying.
4	CaO as $Ca(NO_3)_2$	0.1	Healthy	Healthy.
5	MgO as $Mg(NO_3)_2$	0.05	Healthy	Healthy.
	CaO as $Ca(NO_3)_2$	0.05		
6	MgO as $Mg(NO_3)_2$	0.05	Healthy	Healthy.
	CaO as $Ca(NO_3)_2$	0.1		
7	MgO as $MgSO_4$	0.1	Healthy	Dead.
	K_2O as K_2SO_4	0.1		

On July 23 there were added to the bottles containing plants still living, viz, No. 4, No. 5, and No. 6, 2 c. c. of a 14 per cent nutrient solution, made up as follows:

	Per cent.		Per cent.
KH_2PO_4	5	NaCl	1.25
KNO_3	5	$FeSO_4$	0.25
$(NH_4)_2SO_4$	2.5		

On August 13, twenty-seven days from the time the plants had been set in the culture solutions, they had attained a growth as follows:

No. bottle.	Solution.	Per cent.	Height.	Roots.
			Cm.	*Cm.*
4	CaO	0.1	19	7
5	MgO CaO	0.05 0.05	24	8
6	MgO CaO	0.05 0.1	17	7

The plants in the solutions containing both lime and magnesia were of normal appearance and growth. The plant in No. 4, with 0.1 per cent of lime and no magnesia, exhibited red spots on the leaves, and appeared as though the physiological processes had been interfered with.

On July 30 another series was started, using the cowpea, sprouted as before, and 9 cm. high. To each bottle was added 1 c. c. of a nutrient solution of the composition used in the previous experiment. The following table shows the additional nutrients added and the results:

Results of experiments with cowpeas set July 30.

No. of bottle.	July 30.		August 4.	August 7.	August 13.
	Solution.	Per cent.	Condition.	Condition.	Condition.
8	Check		Growing	Dying at top	Dead. Height, 20 cm. Roots, 8 cm.
9	MgO as $Mg(NO_3)_2$	0.1	Growing	Dying at top	Dying. Height, 24 cm. Roots, 7 cm.
10	MgO as $Mg(NO_3)_2$ CaO as $Ca(NO_3)_2$	0.1 0.05	Growing	Healthy	Healthy. Height, 18 cm. Roots, 11 cm.
11	MgO as $Mg(NO_3)_2$ CaO as $Ca(NO_3)_2$	0.1 0.1	Growing	Healthy	Healthy. Height, 35 cm. Roots, 10 cm.
12	MgO as $Mg(NO_3)_2$ CaO as $Ca(NO_3)_2$	0.1 0.2	Growing	Healthy	Healthy. Height, 28 cm. Roots, 10 cm.
13	MgO as $Mg(NO_3)_2$ FeO as $FeSO_4$	0.1 0.02	Drooping	Dying	Dead. Height, 25 cm.
14	MgO as $Mg(NO_3)_2$ Na_2O as $NaNO_3$	0.1 0.1	Growing	Healthy	Dead. Height, 28 cm.
15	MgO as $MgSO_4$	0.1	Growing	Dejected	Dead. Height, 28 cm.

In this series the cotyledons were attached to the plants when reset, and they, together with the nutrients in the solutions, enabled all the plants to make same growth. However, without exception, they were soon overcome by the noxious influence of magnesia in the absence of lime, while those in solutions containing lime preserved a normal appearance.

On August 13 a series of cultures were started, using cowpeas 30 cm. high. The plants had been sprouted in clean sawdust, and had exhausted the substance stored in the cotyledons. One cubic centimeter of the nutrient solution was added to each bottle, the additional nutrients added, and the results are shown in the following table:

Results of experiments with cowpeas set August 13.

No. of bottle.	August 13.		August 20.	August 27.	September 6.
	Solution.	Per cent.	Condition.	Condition.	Condition.
16	Check		Dejected	Dying	Dead.
17	MgO as $Mg(NO_3)_2$	0.1	Growing	Dying	Dead.
18	CaO as $Ca(NO_3)_2$	0.1	Growing	Healthy	Growth ceased, leaves curling.
19	MgO as $Mg(NO_3)_2$	0.05	Growing	Healthy	Healthy.
	CaO as $Ca(NO_3)_2$	0.05			
20	MgO as $Mg(NO_3)_2$	0.05	Growing	Healthy	Healthy.
	CaO as $Ca(NO_3)_2$	0.1			
21	Na_2O as Na_2CO_3	0.05	Growing	Healthy	Healthy.
	CaO as $Ca(NO_3)_2$	0.1			
22	MgO as $Mg(NO_3)_2$	0.1	Growing	Dying	Dead.
	K_2O as KNO_3	0.1			
23	MgO as $Mg(NO_3)_2$	0.1	Growing	Healthy	Healthy.
	CaO as $Ca(NO_3)_2$	0.05			
24	MgO as $Mg(NO_3)_2$	0.1	Growing	Healthy	Healthy.
	CaO as $Ca(NO_3)_2$	0.1			
25	MgO as $Mg(NO_3)_2$	0.1	Growing	Healthy	Healthy.
	CaO as $Ca(NO_3)_2$	0.2			
26	MgO as $Mg(NO_3)_2$	0.1	Growing	Dropping leaves.	Dead
	FeO as $FeSO_4$	0.02			
27	MgO as $Mg(NO_3)_2$	0.1	Growing	Dying	Dead.
	Na_2O as $NaNO_3$	0.1			
28	MgO as $MgSO_4$	0.1	Growing	Dying	Dead.

In these experiments, with lime and magnesia in solutions, the results under like conditions were very uniform throughout. When the death of the plant ensued there was first noted a shrinkage of the leaf, followed by a browning of the root system and a stoppage in the development. The growth of root hairs, especially, was hindered. As plants sprouted in solid media and transferred to water cultures throw out a different kind of root hair in order to adapt themselves to the new media, it is probable that the first injury in the magnesia solution lies in the deterrent action of that element upon this process.

While the action of magnesia in the absence of lime proved poisonous, the absence of magnesia with lime present when a certain point was reached resulted in the arrested development of the plant. The action of both elements were not in such excess as to produce a physical effect, but rather a physiological one.

The experiments also show that potassium, sodium, and iron salts do not serve in the place of calcium salts in overcoming noxious effects of an excess of magnesia. In general, the potassium and sodium, both as nitrate and sulphate, seemed to reduce to some extent the toxicity of the magnesia, but not to such an extent as to justify their employment in actual practice. The iron sulphate, on the contrary, appeared to increase the toxicity of the excess of magnesia. Loew has already pointed out[1] that magnesia as nitrate and sulphate is alone more noxious to plants than sodium or potassium alone.

In order to test the influence of an excess of magnesia upon the stem and foliage, a series of water cultures were made, using herbaceous branches, about 30 cm. in length, of the privet (*Ligustrum vulgare*). The solutions were made up and the results were as reported in the following table:

Results of experiments with privet set August 23.

No. of bottle.	August 23.		September 15.	October 4.
	Solution.	Per cent.	Condition.	Condition.
29	Distilled water		Normal	Normal.
30	MgO as $MgSO_4$	0.2	Few upper leaves left	
31	MgO as $Mg(NO_3)_2$	0.2	Stem blackened; leaves fallen.	
32	CaO as $Ca(NO_3)_2$	0.2	Leaves curled and mostly fallen.	
33	MgO as $Mg(NO_3)_2$ CaO as $Ca(NO_3)_2$	0.1 0.1	Leaves slightly curled	Leaves mostly fallen; color normal.
34	MgO as $MgSO_4$	0.2	Stem blackened; leaves fallen.	
35	MgO as $MgSO_4$ CaO as $Ca(NO_3)_2$	0.1 0.1	Normal	Normal.

From the foregoing tables it will be noticed that an excess of magnesium salts in the absence of calcium salts proved noxious to the extent of killing the plant. Where calcium salts were used without magnesium the plant made a slow growth for a while, but later ceased growing and exhibited phenomena of starvation—the development being arrested and the leaves assuming a light shade of green. Where the magnesium and calcium were used in conjunction, the plants in every instance made a healthy growth. In such combination the best final growth was made in a solution where the lime was in moderate excess of the magnesia, and the total amount of soluble salts, including nutrient, did not exceed 0.3 per cent.

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[1] Bul. No. 18, U. S. Dept. Agr., Veg., Phys., and Path.: "Physiological rôle of chemical nutrients."

The uniformity in the favorable results with the different lime salts in overcoming the poisonous effects of an excess of magnesia indicate that the action was due to the basic and not to the acid radical. Should there be a favorable action of the acid radical in this relation it would appear in cases where a magnesium salt was employed with such an acid radical. The uniform toxic effect of the magnesia in excess without lime, and the elimination of that effect in the presence of lime, indicate that the acid radical of the salt has none or at least very little influence in the matter aside from favoring solubility, as further experiments prove. Lime appears to be the only antidote, as far as the elements were tested, for combating an excessive amount of magnesia.

LIME AND MAGNESIA AS CARBONATES IN SAND CULTURE.

In order to further study the relation of lime and magnesia to each other in their effect upon plant growth other experiments were planned.

To 60 kilograms of clean, white quartz sand there were added the following compounds:

	Per cent.
CaO as $CaCO_3$	0.4
P_2O_5 as $Ca_3(PO_4)_2$	0.2
H_2SO_4 as $CaSO_4$	0.1
$FeSO_4$	0.1

To 30 kilograms of the sand there were added MgO as $MgCO_3$, 0.1 per cent; and to the remaining 30 kilograms, MgO as $MgCO_3$, 1 per cent. The chemicals were rubbed up in a mortar, added to a small portion of the sand, and then to the whole amount. The sand was put into twelve pots, holding 5 kilograms each. Those with the minimum amount of magnesia were marked *1A* to *6A*, inclusive; those with the maximum amount, *7B* to *12B*, inclusive.

EXPERIMENTS WITH TOBACCO.

In the first series, marked *A*, the portion of CaO to MgO was 15 to 1. In the second series, marked *B*, the porportion of CaO to MgO was 3 to 5. On January 6, tobacco plants 5 cm. high were taken from rich soil, the roots carefully washed, and were set in the sand. A nutrient solution was made up consisting of KNO_3, 10 per cent; NH_4NO_3, 10 per cent; H_2KPO_4, 1 per cent. There was added each week to each pot 1 c. c. of this solution.

The plants in the *A* pots continued to grow, were of normal appearance, and good color. The plants in the *B* pots ceased growing after they were planted; the lower leaves turned yellow and died, the upper contracted, became thickened and wrinkled, and acquired a deeper shade of green.

On March 7, when the experiment was closed, the plants in *A* pots were healthy, of good color, and with twelve to thirteen leaves; height, from 16 to 20 cm. Plants in *B* pots were nearly dead, apparently atrophied, with from two to three leaves, and were from 3 to 4 cm. high. For samples of these plants, see Pl. I.

A very similar experiment was made as follows: To 20 kilograms of sand, washed with dilute hydrochloric acid, there was added nutrients, as in the preceding case, except that in the *A* pots the percentage of MgO as carbonate was increased, making the proportion of CaO to MgO as 10 to 1, while in the *B* pots the proportion of CaO to MgO was as 1 to 2, the total amount of the MgO being 1 per cent of the whole culture medium. The nutrient solution was added each week as in the previous case. The pots were watered with distilled water.

On February 8 tobacco plants grown in rich soil, and about 5 cm. high, were taken, the roots carefully washed, and set in the sand in 3 pots of each series. In the remaining 6 pots barley was planted.

On March 7 the tobacco plants in *A* pots were in healthy, normal condition, height 7 to 10 cm., of good color, thrifty, and with seven to eight leaves. The tobacco plants in *B* pots were stunted, 2½ to 4 cm. high, lower leaves dead or dying, upper leaves dark green, thickened, and wrinkled. The plants were apparently dying by atrophy; number of leaves, three to four.

The barley in the *A* pots was 14 to 27 cm. high and in a normal, healthy condition. The plants in the *B* pots were 4 to 5 cm. high and diseased.

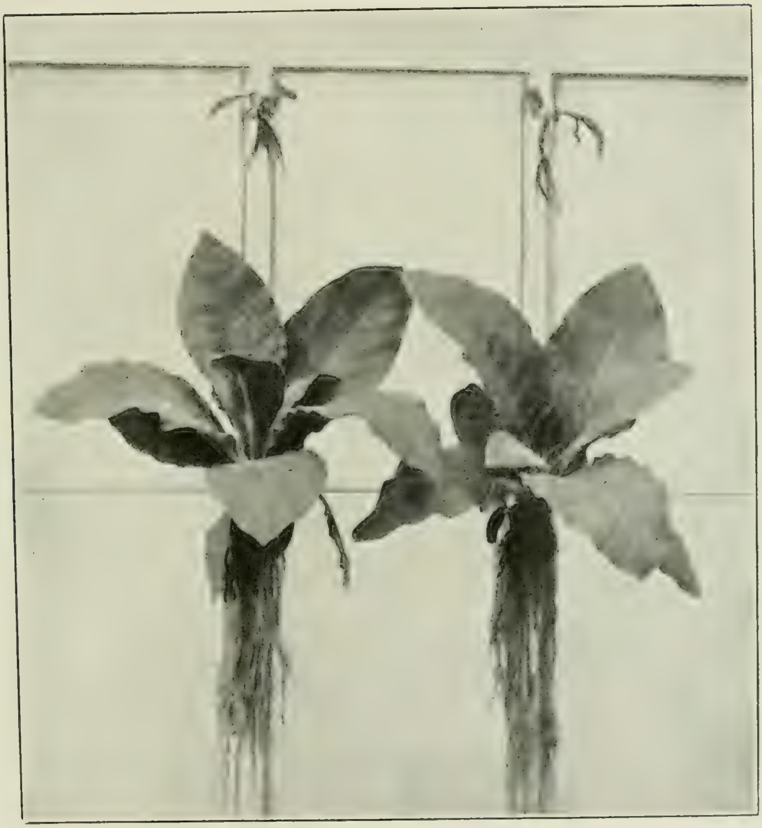
In these experiments the action of an excess of magnesia in the soil seemed to result in the cessation of growth in the plant and the thickening and wrinkling of the leaf, at the same time the leaf assumed a deeper shade of green and showed a tendency to curl. The roots showed little development, were without root hairs, and after some time became shriveled, and assumed a dark brown color.

To the pots in the preceding experiment marked *B* and containing 1 per cent of MgO as carbonate there was now added enough CaO as carbonate to make the proportion of CaO to MgO in three as 1 to 1 and in the other three as 2 to 1. This was done with the object in view of determining the effect of calcium carbonate in overcoming the noxious influence of an excess of magnesium carbonate.

EXPERIMENTS WITH BARLEY.

On April 21 the pots were planted to barley which was sprouting on the 26th. On May 7 the plants were of good color, but on the 8th became slightly yellow, and upon examination showed an unhealthy root system. On May 23 the plants were making no growth and were removed.

On May 26 tobacco plants 7 cm. high were set in the same pots and barley was also replanted. June 4 the tobacco was making no growth



TOBACCO FROM SAND CULTURES.

Upper plants, excess of magnesia; lower plants, excess of lime.

and lower leaves were dying. To one pot of each proportion there was added daily until June 18 one-fourth gram, or a total amount of 3.5 grams of CaO as nitrate. On June 9 the plants were all making but little growth, those in pots to which the nitrate was added making the best appearance. June 25 the roots of the tobacco and barley were dead. The barley had made a growth of from 7 to 10 cm.; tobacco, no growth at all.

EXPERIMENTS WITH OATS, WHEAT, AND BEANS.

In the same soils trials were made with oats, wheat, and beans with similar unsatisfactory results. It appeared as time passed that the calcium carbonate had a slight influence in overcoming the toxicity of the magnesia, but its effect was of slow action. In these experiments the magnesia was very finely divided, and it is believed that the failure in this instance was due to the great fineness of the magnesia preparation and its greater solubility over the lime. In one of the pots in this experiment 0.4 per cent of $CaSO_4$ was added. In this case the plants continued to grow in a normal manner, while in the pots to which the sulphate had not been added the injurious results continued. This addition of the sulphate permitted of the due action of the lime by presenting it in a more finely divided and more soluble form.

C. Schreiber[1] found that when lime was lacking in certain experiments germination was much retarded. Potatoes under these conditions were found after three or four months in almost the same state as when planted. In overcoming this the action of calcium sulphate was much more effective than the action of burnt lime and carbonate of lime. In experiments with two fertilizers, the first containing dicalcium phosphate, sulphate of lime, and carbonate of magnesia, the second, phosphate of soda, carbonate of lime and magnesia, in every case the yield was much lower with the latter. This was due, the author states, to the action of the carbonate of lime and magnesia in rendering the phosphate of soda insoluble. At the Rhode Island experiment station, where various forms of lime were tested for neutralizing acid soils, the carbonate was found to be most effective.

The experiments of the writer with the carbonate show that in overcoming the noxious effects of magnesia its action was very slow, owing apparently to its not being in a finely divided condition and its difficult solubility. At the New York State experiment station[2] no results were obtained on sorghum with carbonate of lime applied the same season. Wheeler states[3] that calcium sulphate is believed to act more energetically than carbonate of lime, air-slacked or water-slacked lime in liberating potash for the use of plants in soil.

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[1] Revue Agronomique, Vol. IV, No. 1.

[2] Report New York State Exp. Sta. for 1891.

[3] Farmers' Bulletin No. 77.

LIME AND MAGNESIA AS CARBONATES IN SOIL CULTURES.

To further test the influence of calcium and magnesium as carbonates on the growth of plants soil cultures were made. In this experiment a sea-island cotton soil was employed, consisting largely of sand with some silt and clay. The particles were finely divided, 1 kilogram passing through a 2-mm. sieve, leaving a residue of only 1½ grams. Analyses showed a large amount of iron but a very small amount of lime and magnesia.

To the soil there was added:

	Per cent.		Per cent.
KH_2PO_4	0.2	$(NH_4)_2SO_4$	0.2
KCl	0.1	KNO_3	0.1

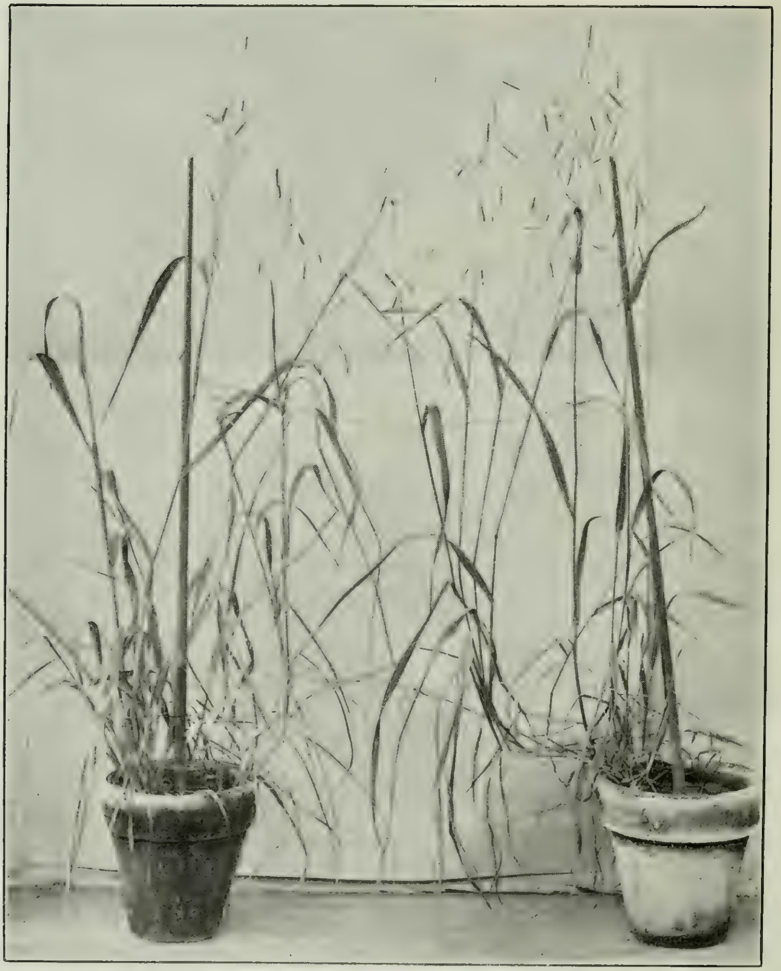
The soil was put into twenty pots, a series of nine in duplicate and two extra. Lime and magnesia as carbonate was incorporated, as in the following schedule:

No. pot.	CaO.	MgO.
	Per cent.	*Per cent.*
1	0.9	0.1
2	0.8	0.2
3	0.7	0.3
4	0.6	0.4
5	0.5	0.5
6	0.4	0.6
7	0.3	0.7
8	0.2	0.8
9	0.1	0.9
10	0.8	0.2
11	0.2	0.8

EXPERIMENTS WITH OATS AND COWPEAS.

One series of pots, Nos. 1 to 9, holding 1 kilogram each of soil, was planted to oats, the other to cowpeas, and were watered with distilled water. The seed germinated first and plants were best beginning with the pots containing the largest amount of lime and the smallest amount of magnesia, and ranging down in thriftiness to those containing the smallest amount of lime and the greatest amount of magnesia. Later the best growth of both oats and cowpeas was in the soils containing CaO 0.8 per cent and MgO 0.2 per cent. In all cases where the CaO was 0.6 per cent and less and the MgO was 0.4 per cent and more the plants made a very sickly growth or else died outright. In the two extra pots planted to tobacco, No. 10, with CaO 0.8 per cent and MgO 0.2 per cent, the plant made a normal growth, while in No. 11, with CaO 0.2 per cent and MgO 0.8 per cent, the plant became atrophied and died. In these cases the action of the lime in counteracting the noxious influence of the magnesia was at most very limited.

To further test the matter, there was added to five pots containing 0.5, 0.7, 0.8, and 0.9 per cent of MgO 0.4 per cent of CaO as sulphate,



Oats in sterile Magnesium Soils rendered fertile by the Addition of
$MgSO_4$ $CaSO_4$

making the proportion of CaO as sulphate to MgO as carbonate as follows: 4 to 5, 4 to 6, 4 to 7, 4 to 8, and 4 to 9, respectively, or, counting the calcium carbonate previously added, CaO to MgO as 9 to 5, 8 to 6, 7 to 7, 6 to 8, and 5 to 9. In the pots oats were replanted, and in the course of nine days were uniformly sprouted in each pot. They continued to grow, were of good color, thrifty, and were free from shriveling of the root system, as was the case before the calcium sulphate was added. These plants were brought to maturity, producing seed. (See Pl. II.) The growth in the five pots appeared to be normal except in the last, containing a total of CaO 0.5 per cent, or as sulphate 0.4, and MgO 0.9 per cent. Here, while there was a moderate development of the plant, it did not show the thrifty condition of the other plants in the soils containing more lime, indicating that there was not enough calcium in soluble form to wholly counteract the injurious effects of the magnesia.

While the plants in the pots to which calcium sulphate had been added were growing, the pots containing the carbonates were replanted from time to time. The injurious results were continuous during the several months, the calcium carbonate not being able during a period of that length to counteract the effect of the excess of magnesia.

LIME AND MAGNESIUM AS NITRATES IN SAND CULTURES.

In order to test the two bases, calcium and magnesium, in a more soluble form, sand cultures were made in which these two elements were applied in the form of nitrates. These series of cultures were made to test the relation of the two bases to each other, and to find that ratio between the two that offered the best conditions for the growth of plants.

There was added to 30 kilograms of pure white sterilized sand the following:

	Per cent.
K_2HPO_4	0.1
KH_2PO_4	0.1
KNO_3	0.2
$(NH_4)_2SO_4$	0.1
$FeSO_4$	Trace.

These salts were finely powdered, mixed with a small quantity of sand, and then with the whole. The sand was put into sixteen pots, in two series of eight each, and calcium and magnesium nitrates added in solution in such proportion as to correspond to the following ratios:

To 2 *A* pots, MgO, 0.8 per cent; CaO, 0.1 per cent.
B pots, MgO, 0.7 per cent; CaO, 0.2 per cent.
C pots, MgO, 0.6 per cent; CaO, 0.3 per cent.
D pots, MgO, 0.5 per cent; CaO, 0.4 per cent.
E pots, MgO, 0.4 per cent; CaO, 0.5 per cent.
F pots, MgO, 0.3 per cent; CaO, 0.6 per cent.
G pots, MgO, 0.2 per cent; CaO, 0.7 per cent.
H pots, MgO, 0.1 per cent; CaO, 0.8 per cent.

EXPERIMENTS WITH WHEAT AND OATS.

On July 11 the pots were planted to wheat. On July 18 the wheat plants had made growths as follows:

MgO.	CaO.	Growth.
Per cent.	*Per cent.*	*Centimeters.*
0.1	0.8	2.5
0.2	0.7	2.5
0.3	0.6	12
0.4	0.5	18
0.5	0.4	15
0.6	0.3	5
0.7	0.2	5
0.8	0.1	2.5

On July 23 the growths made were comparatively as reported above (see Pl. III, fig. 1).

On August 6 the plants in one series of pots were taken up and the root system examined, with the following results: In pots with—

MgO.	CaO.	Growth.	Condition.
Per cent.	*Per cent.*	*Centimeters.*	
0.1	0.8	6	Bushy, poorly developed.
0.2	0.7	6	Bushy, poorly developed.
0.3	0.6	16	Bushy, well developed.
0.4	0.5	16	Bushy, well developed.
0.5	0.4	7	Poorly developed.
0.6	0.3	3	No root hairs.
0.7	0.2	3	No root hairs.
0.8	0.1	4	No root hairs.

As in the growth above ground, the root systems showed the most favorable conditions to be present where the amount of soluble CaO was slightly in excess of the soluble MgO. Where the CaO was in great excess the root system was apparently healthy, but poorly developed. When the MgO was in greatest excess the root system showed an unhealthy condition, the absence of root hairs, and later the shrinkage and discoloration of the larger portion of the root.

On August 20, forty days from the time of planting, the wheat in the remaining series of eight pots, with the exception of the extremes, had become more equal in height. The general thriftiness of the plants, however, appeared to range as before reported, the pots with lime moderately in excess of magnesia making the best growth, the plants in the pot with MgO 0.4 per cent and CaO 0.5 per cent being larger and stronger, and the thriftiness ranging from this ratio down to MgO 0.2 and CaO 0.7, and MgO 0.7 and CaO 0.2 per cent. In the two extreme pots the plants were dead.

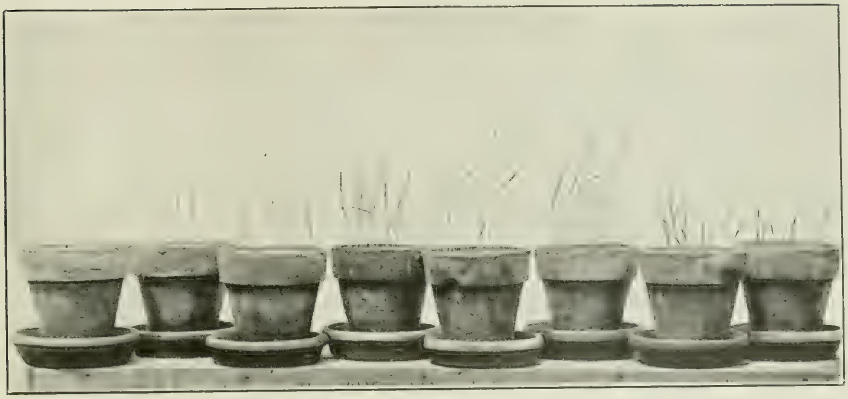


FIG 1.—WHEAT IN SAND CULTURES.

Pots from left to right ranging in MgO 0.8 to 0.1, CaO 0.1 to 0.8 per cent as nitrates.

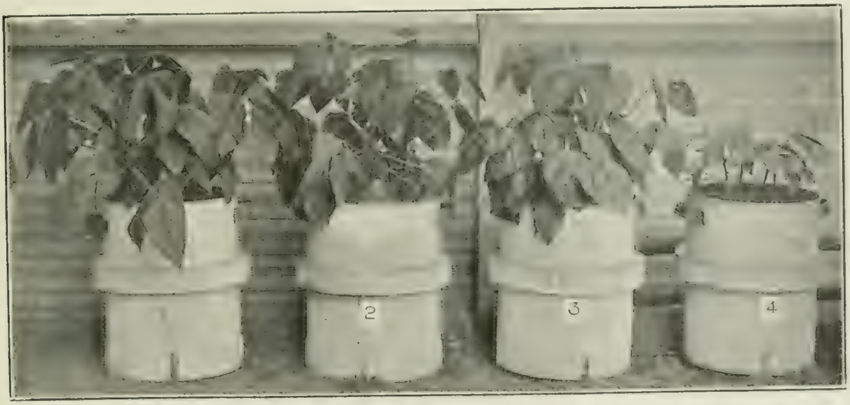


FIG. 2.—COWPEAS IN SOILS SHOWING EFFECT OF VARIABLE APPLICATIONS OF LIME AND MAGNESIA.

It will be observed that the amounts of soluble salts in this experiment were very largely in excess of the needs of the plants. They were made so in order to thoroughly test the capacity of the lime in counteracting the noxious influence of the magnesia, and the bases were not added with the view of conserving the best conditions of plant growth or with the idea of bringing them to their full development.

The experiments tend to show that the most favorable condition for the growth of wheat is in the soil where the amount of available lime is in moderate excess over the amount of available magnesia. If the amount of magnesia is too small in the presence of a larger percentage of lime the plant shows phenomena, apparently, of starvation. If the amount of magnesia is excessive, with a deficiency of lime, the magnesia exerts a poisonous influence upon the plant.

The Deutsche Landwirtschaftliche Presse[1] states that calcium carbonate in the soil to the amount of 0.46 per cent had an injurious effect upon lupins, and that this was overcome by an application of kainit. The action of kainit in this case was probably due to its magnesia content.

In a trial with oats in these series of pots the results were as with wheat—the germination was quickest and growth best in the pots with MgO 0.4 and CaO 0.5 per cent.

EXPERIMENTS WITH COWPEAS.

After the removal of the wheat one series of pots was planted to cowpeas and one to tobacco. With the cowpeas the results of the most favorable ratio of lime to magnesia was the same as with wheat. The seed germinated in the same order, the ratio of CaO 0.5 and MgO 0.4 being the more favorable, and the growth of plants decreasing from that pot to the two extremes. The cowpeas, however, appeared to be more tolerant of the excess of the two salts in the extreme pots, and after germination the plants grew better than the wheat plants. Since the cowpea contains more of the mineral nutrients stored up in its seeds than wheat grains, the evil effects of an excess of magnesia or lack of lime in the soil can be better counteracted up to a certain stage in the development of the plant.

EXPERIMENTS WITH TOBACCO.

To the second series of eight pots tobacco plants about 5 cm. high were transplanted from soil. Beginning with the pot containing CaO 0.8 and MgO 0.1 per cent, the plant started into quickest growth, showing the greediness of this plant for lime. Later, however, this plant became spindling and of light color, while the plants in the pots with MgO 0.2 per cent, CaO 0.7 per cent, MgO 0.3 per cent, and CaO 0.6 per cent made a better growth and were of normal proportions and of good color.

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[1] Vol. 23, Nos. 91 and 92.

The figures for the best proportions of lime to magnesia in soils for the early germination and quick development of plants refer, of course, to the soluble amounts—that is, to that portion directly available to the immediate needs of the plant. These figures are therefore arbitrary in agricultural practice, owing to the variation of the solubility of these elements in the soil. It will also be noticed that soluble magnesia in excess of soluble lime in small amounts may have a deterrent action upon plant growth while not becoming noxious to the extent of killing the plant. Also, lime may be in a great excess over magnesia, and yet there may be enough of the latter element available to respond to all the requirements of the plant.

LIME AS SULPHATE AND MAGNESIA AS CARBONATE IN SOIL CULTURES.

From the preceding experiments the favorable action of gypsum in counteracting the toxic action of magnesia is apparent. From an agricultural standpoint it is, besides, the most available form for liming because of its cheapness as compared with other of the more soluble forms of lime.

To further test the action of gypsum in combination with an excess of magnesia, cultures were made up in iron pots holding 30 kilograms each. The soil had the following composition:

	Per cent.		Per cent.
Fine gravel	0.65	Silt	21.79
Coarse sand	4.20	Clay	9.80
Medium sand	9.40	Loss on ignition	3.67
Fine sand	30.55		
Very fine sand	20.14	Total	100.20

Soluble in 1.115 per cent hydrochloric acid: CaO, 0.14 per cent; MgO, 0.144 per cent.

Four pots were made up as follows, using magnesia where applied as carbonate and lime as sulphate:

No. pot.	Solution.	Per cent.
1	Check	
2	CaO	0.8
3	MgO CaO	0.2 0.8
4	MgO CaO	0.68 0.2

EXPERIMENTS WITH COWPEAS.

The four pots were planted to cowpeas April 12. On April 22 plants were up in Nos. 1, 2, and 3, and on the 25th in No. 4. On May 15 the plants were all thrifty, and the following shows the growths on that date and on June 14:

GROWTH ON MAY 15.	Centimeters.
Nos. 1 and 2	20
No. 3	18
No. 4	15

GROWTH ON JUNE 14.	Centimeters.
No. 1	34
No. 2	35
No. 3	34
No. 4	19

Nos. 1, 2, and 3 were very much alike in general thriftiness and were of a uniform dark-green color. No. 4 was spindling and of a light-green color. On June 26, one and one-half months from planting, a photograph was taken of the four pots. (See Pl. III, fig. 2.) No. 1 is the check; No. 2, CaO, as sulphate, 0.8 per cent; No. 3, CaO, as sulphate, 0.8 per cent; MgO, as carbonate, 0.2 per cent; No. 4, CaO, as sulphate, 0.2 per cent; MgO, as carbonate, 0.68 per cent.

It will be noticed that the addition of an excess of calcium sulphate did not cause a deterrent effect in the presence of 0.144 of soluble magnesia, nor did the addition of more magnesia in No. 3 produce a favorable effect over the check, showing that the magnesia already present was sufficient for the plants grown. As shown by the check, No. 1, 0.14 per cent of soluble lime was also sufficient for the direct needs of the plant. In No. 4, with the addition of 0.68 per cent of magnesium carbonate and 0.2 per cent of calcium sulphate, the noxious influence of the former is apparent. While not sufficient to cause the death of the plants, it hindered their growth to such an extent as to preclude the possibility of the production of a profitable crop.

While liming may be profitably carried on for bettering the physical condition of soil, the correction of acidity, and other reasons, it may also in certain cases be beneficial from a physiological standpoint. The need for it may be surmised from an analysis of the soil. Though only the soluble lime and magnesia affect the immediate growth of plants in a given soil, it is apparent that where one element is in great excess of the other it will naturally be present in larger proportion in the soil solution.

When the magnesia content of the soil is large and the application of calcium sulphate is expensive, the determination of the soluble salts would be advisable before liming. However, in that case the application of lime, though lessened, would be of only temporary advantage, as successive applications would be needed. In this connection, it would be of value to construct a table showing the curve of solubility of lime and magnesium salts in the same culture medium or solution.

The experiments herein reported show that where the lime and magnesia are in a wholly soluble condition, the plants germinated quickest and made the more rapid growth where the lime was in slight excess over the magnesia. In actual practice the case can not be governed so closely, for then we are dealing with a very complex combination—the soil. Moreover, it is hard to determine at each stage the form in which the lime and magnesia exists in the soil. Again, different plants are variously affected by an excess of magnesia in soils. In practice, therefore, it is difficult to lay down hard and fast rules for liming the soils for physiological results.

As borne out by experiments, gypsum appears to be, all things considered, the most available form of lime to apply in overcoming the noxious influence of an excess of magnesia. An excess of gypsum is little to be feared, as the plant seems to be able to use magnesia if present in sufficient amount for its direct needs, whether gypsum be present in large amount or small. On the other hand, a lack of lime in a soluble form is more to be guarded against, for in this case the magnesia, if in a certain excess, will be assimilated to the detriment of the plant. Magnesium carbonate we found might be in a slight excess over calcium sulphate, and normal healthy growth of the plant be made. However, this excess should be small, not greater, with cereals, than 2 to 1. With cowpeas, as shown, a ratio of MgO as carbonate 0.68 to CaO as sulphate 0.2 per cent, while not toxic to the extent of killing the plant, was so injurious as to prevent profitable growth. In these cases the solubility of the salts in the soil were not determined. In liming, therefore, for any purpose, it is advisable to know the lime and magnesia content of the soil, both the soluble and total, as well as the content in the fertilizer applied. Underliming is more to be guarded against than overliming, care being taken that magnesian limestone is not applied where an excess of magnesia is already present.

SUMMARY.

Soil analyses show that lime and magnesia are widely distributed in soils and generally in sufficient quantities for the direct needs of plants. They are not always in the best proportions to each other, from a physiological standpoint, for favoring plant growth.

Magnesia in a soil in great excess over lime in a finely divided or soluble condition is noxious to the growth of plants. With a great excess of lime over magnesia the physiological action of the plant is hindered and it exhibits phenomena of starvation. An excess of lime counteracts the poisonous effects of magnesia, while the more favorable proportion of the two bases obviates the poor nutrition of the plant.

The best proportion of soluble lime to soluble magnesia for the germination and growth of plants is about molecular weight 5 to 4, or actual weight 7 to 4.

The more soluble forms of magnesia, as nitrate and sulphate, are in excess more injurious to plants than the less soluble as carbonate, while the more soluble forms of lime as sulphate and nitrate are more efficient in overcoming the noxious effects of magnesia than less soluble forms as carbonate.

In applying fertilizers containing magnesia, as in the crude potash salts, liming should be carried on in conjunction unless the soil is known to contain an excess of lime. Where the lime content of the soil is about equal to or less than the magnesia content, lime in a finely divided form, as sulphate, should be supplied with the fertilizer in an amount in excess of the magnesia present in the latter.

In liming soils the amount of lime and magnesia should be first determined in both the soil and the material applied. In this way only can the process be intelligently carried out and the best ratio between the two bases for the promotion of the growth of crops be maintained.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN No. 2.

B. T. GALLOWAY, Chief of Bureau.

SPERMATOGENESIS AND FECUNDATION OF ZAMIA.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief.
Washington, D. C., August 1, 1901.

Sir: I have the honor to transmit herewith the manuscript of a paper entitled Spermatogenesis and Fecundation of Zamia, by Dr. Herbert J. Webber, Physiologist, in Charge of the Plant Breeding Laboratory, Vegetable Pathological and Physiological Investigations, this Bureau. I respectfully recommend its publication as Bulletin No. 2 of the Bureau series.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The following technical paper on the Spermatogenesis and Fecundation of Zamia, by Dr. Herbert J. Webber, embodies the results of investigations started by him several years ago at our tropical laboratory in Florida. The time at his disposal for this work was very limited, so that it has extended over a much longer period than was at first expected.

As an aid to the practical work of plant breeding it is highly important that a more thorough knowledge of the reproduction of plants be gained. Such investigations throw light on the phenomena of heredity, which are at the foundation of plant breeding work. The present paper is of especial interest because the large size of the sexual nuclei in Zamia has enabled Dr. Webber to work out some of the phenomena of fecundation with greater exactness than has ever been done before.

Albert F. Woods.

Office of the Pathologist and Physiologist,
Washington, D. C., July 20, 1901.

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SPERMATOGENESIS AND FECUNDATION OF ZAMIA.

By Herbert J. Webber,
Physiologist.

INTRODUCTION.

Within recent years renewed interest has been awakened in the phenomena accompanying spermatogenesis in plants, due largely to researches on certain cycadaceous plants and Pteridophytes in which the cilia of the spermatozoid have been found to develop from a body resembling a centrosome. This interest was greatly enhanced by the fact that the enormous spermatozoids of the Cycadaceæ and *Ginkgo* were but newly discovered, and in groups of plants where motile sexual cells had not been known to occur. Zoological activity in this direction has also been very great in recent years, a number of cases having been described in which it is claimed that the axial filament is developed directly from the centrosome which here forms the so-called middle piece (*Mittelstück*) of the spermatozoon.

The writer's investigations on the spermatogenesis and fecundation of *Zamia* and *Ginkgo* began in 1897, and since that time several preliminary papers and short notes have been issued in various places. In 1897 three preliminary papers were published in the Botanical Gazette and a short note in the Report of the British Association for the Advancement of Science. In 1898 additional observations were described in a report read at the American Association for the Advancement of Science, and in 1900 still further observations, particularly on the morphology and development of the pollen tube apparatus, were described. The present paper covers the ground connectedly, more in detail, and with illustrations. The investigation is of considerable interest as throwing light on the phenomena accompanying fecundation and on the relation of the cilia-forming organs of spermatogenous cells to centrosomes or centrospheres.

SUMMARY OF RECENT LITERATURE.

The following summary of the recent literature on the spermatogenesis of Pteridophytes, cycadaceous plants, and *Ginkgo*, arranged in order of publication, will give an idea of the advancement of our knowledge in this direction.

The occurrence of spermatozoids in *Ginkgo* was first announced by Hirase, a Japanese botanist, in a short note in Japanese in the Botanical Magazine of October, 1896, and a few months later in a preliminary contribution, "Untersuchungen über das Verhalten des Pollens von *Ginkgo biloba*," published in Botanisches Centralblatt, Nos. 2 and 3, Band 69, appearing January, 1897. The important features here described, other than the fact of the occurrence of motile spermatozoids in one of the phanerogams where they had never before been known to occur, was the structure of the mature spermatozoid, which was described as consisting of a nucleus completely surrounded by cytoplasm. While Belajeff had strongly maintained that the cytoplasm entered into the structure of the spermatozoids of certain ferns and of *Chara*, this was yet considered doubtful. Hirase says:

> Die Spermatozoiden von *Ginkgo* haben eine andere Gestalt als die der höheren Kryptogamen. Sie sind eiförmig, 82μ lang bei 49μ Breite; in der Mitte sitzt der Zellkern, welcher durch Cytoplasma völlig umschlossen ist. Der Kopf besteht aus drei nie erstreckbar gebauten Spiralwindungen, worauf viele Cilien wurzeln, auch ist ein spitzer Schwanz vorhanden.

About the same time (November 20, 1896) Professor Ikeno, another Japanese botanist associated with Hirase in the University of Tokyo, announced the discovery of spermatozoids in *Cycas*. The first announcement appeared in the Botanical Magazine, November 20, 1896, and was almost immediately followed by a short statement in Botanisches Centralblatt (61). Here, as in the case of Hirase's preliminary announcements above referred to, the articles are limited to a simple statement of the occurrence of the spermatozoids and their structure, nothing being given as to their development. Ikeno wrote:

> Sie sind etwas grösser als die letzteren [those of *Ginkgo*] und enthalten Zellkern und Cytoplasma. Der Zellkern nimmt den mittleren Theil derselben ein und wird von dem Cytoplasma völlig umhüllt. Der Kopf besteht aus vier Spiralwindungen und trägt sehr reichlich Cilien. Im pollinschlauch findet man zur richtigen Zeit je zwei durch die Theilung der generativen Zelle entstandene Spermatozoiden.

In the June, 1897, number of the Annals of Botany, Ikeno and Hirase (68) together published a short note in English announcing the discovery of spermatozoids in *Cycas* and *Ginkgo*. However, no important additional facts were given.

In the June, 1897, number of the Botanical Gazette the writer's first preliminary paper, entitled "Peculiar Structures Occurring in the Pollen Tube of *Zamia*," appeared. The pollen tube apparatus was described and the central cell (generative cell) was traced through its growth up to the close of its division just preceding the formation of the spermatozoids. Very large centrosome-like bodies were found in the central cell and their growth, structure, separation of outer membrane into segments during division, and disconnection with spindle formation was described and figured. The discovery of motile spermatozoids was also announced, but their development was not explained.

In the July, 1897, number of the Botanical Gazette the writer's second preliminary paper on "The Development of the Antherozoids of *Zamia*" appeared. The membrane formed from the outer wall of the centrosome-like body was found to grow into an extended band which assumed the form of a helicoid spiral, became appressed against the plasma membrane of the cell, and gave rise to the cilia of the spermatozoid. The cilia appear first as small protuberances on the band and gradually grow in length until mature. The structure of the mature spermatozoids, their motions in the pollen tube and while swimming free in sugar solutions, were described and figured. Their action in the process of fecundation was also described.

Almost simultaneously with the publication of the writer's second preliminary paper on "The Development of the Antherozoids of Zamia," Belajeff, a Russian botanist, published two preliminary papers describing the presence of a cilia-forming organ or *Nebenkern* in the spermatids of Filicineæ and Equisetineæ (8 and 9), which is doubtless identical with the similar organ in *Zamia* and *Ginkgo*. They apparently originate in the spermatids, since no trace of them could be discovered in the spermatid mother-cells in the resting condition or during karyokinesis. The first changes visible in the metamorphosis of the spermatid cells occur in these organs. They gradually become extended into a thread which assumes the form of a helicoid spiral of which the extended turns of the posterior end surround the nucleus. The cilia of the spermatozoids are developed from the anterior end of this spiral, appearing first as small protuberances on the thread, which finally become greatly extended and form the cilia.

In the October number of the Botanical Gazette the writer's third preliminary paper, "Notes on the Fecundation of Zamia and the Pollen-tube Apparatus of Ginkgo," appeared. In this paper the important features described were that in the fecundation of *Zamia* the spermatozoid enters the protoplasm at the apex of the egg cell where it undergoes disintegration, the nucleus escaping from the cytoplasm and spiral band of the spermatozoid and passing thence alone to the egg nucleus with which it unites. The fecundation is thus a union of cells, the cytoplasmic structures of the spermatozoid fusing with the cytoplasm of the egg cell, while the sperm nucleus passes on and fuses with the egg nucleus. The spiral band which is developed from the centrosome-like body was shown to have no connection with the process of fecundation, remaining, after the escape of the nucleus, intact at the apex of the archegonium and gradually disappearing during the development of the embryo. The centrosome-like bodies in the generative cell of *Ginkgo*, first described by Hirase and termed "attractive spheres" (56), were found to originate *de novo* in the cytoplasm, and their undoubted identity with the centrosome-like bodies in *Zamia* was pointed out. These bodies in *Zamia* and

Ginkgo, being distinct from typical centrosomes in their main function, namely, that of forming the motile cilia of the spermatozoid, were here named *blepharoplasts.*

Early in 1898 Ikeno, in a short paper in Flora (69), announced the occurrence in the spermatids of *Cycas revoluta* of cilia-forming organs like the blepharoplasts of *Zamia*, and claimed that these and the *Nebenkern* of the Filicineæ and Equisetineæ are nothing but genuine centrosomes.

Later in 1898 Shaw (102) described the occurrence of blepharoplasts in the spermatid mother cells of *Onoclea* and *Marsilia* which developed into a cilia-bearing band, as in the cases described by Belajeff. Shaw, however, was able to demonstrate the occurrence of similar bodies in the primordial mother cells (*Urmutterzellen*). At the close of the division which gives rise to the primordial mother cells small round bodies, called by Shaw *blepharoplastoids*, became visible. During the resting stage of the nuclei the blepharoplastoids divide into two, increase in size, and remain near the nucleus. As soon as the nuclei of these cells prepare to divide the pair of blepharoplastoids move away from the necleus and take a position at one side in the cytoplasm about midway between the pole and the equator of the spindle until near the end of the metakinesis stage, when they disappear. The blepharoplasts proper appear as very small bodies, one at each pole of the spindle, about the time that the *blepharoplastoids* disappear, or occasionally slightly before. During the resting stage of the spermatid mother cells the blepharoplast divides into two, and these gradually separate and move to a position in the cytoplasm near where the poles of the next spindle is formed, but always slightly to one side of this. After the completion of the division they become extended into the cilia-bearing band.

In June, 1898, Hirase's complete monograph on the fecundation and embryology of *Ginkgo* appeared (62), describing in detail the development of the spermatozoids. The cilia of the spermatozoids are here developed from a membrane, which is formed from the blepharoplast, the same as in *Zamia*, differing only in minor details. The writer considers the blepharoplast to be nothing more than a centrosome and calls it such throughout his monograph. Hirase described the spermatozoids of *Ginkgo* as having a well-developed tail attached to the posterior end, which would make them seemingly quite different from the spermatozoids described by the writer. Many features of this monograph will be discussed in the present paper in comparison with *Zamia*.

In the report of the Boston meeting of the American Association for the Advancement of Science, published in Science November 11, 1898, the writer (127) described the phenomena connected with the bursting of the blepharoplast in *Zamia* at the close of the division giving rise to the spermatids and the formation of the cilia-bearing band.

The blepharoplast was described as increasing in size and separating into segments or plates, which ultimately form numerous round or elliptical granules that collect into a compact mass in the place occupied by the blepharoplast. These granules gradually fused together, forming the cilia-bearing membrane of the spermatozoid.

Slightly later in the same month, November 23, Ikeno's complete monograph on the development of the sexual organs and the process of fecundation in *Cycas revoluta* appeared (70). The details of the development of the spermatozoids, described by Ikeno for *Cycas*, are almost entirely identical with those previously described by the writer for *Zamia*, differing only in two important details—the connection of a protuberance from the nucleus with the ciliferous band during its growth and elongation and in the presence of a tail attached to the posterior end of the spermatozoid. In the fecundation of *Cycas*, as in that of *Zamia*, the ciliferous band and cytoplasm remain at the apex of the archegonium, the nucleus only fusing with the egg nucleus. Many features of this monograph will be discussed in the present paper in comparison with *Zamia*.

In December, 1898, Fujii (39 and 40), another Japanese botanist, called attention to an apparently serious contradiction between the observations of Ikeno, Hirase, and the writer as to the presence of a tail in the spermatozoids, and described the results of observations made on the living spermatozoids of *Ginkgo*. He concluded that Hirase was in error in claiming the presence of a tail in *Ginkgo* and thinks the appendage supposed by Hirase to be a tail was a malformation due to compression in the escape of the spermatozoid from the pollen tube. Similar conclusions have been reached by Mr. Bessey (15), one of the writer's associates, after a careful examination of living material.

In July, 1899, Belajeff (14) brought forward further evidence to show that the blepharoplast must be considered a centrosome. He found by a careful study of *Marsilia* that the blepharoplast here not only occupies the pole of the spindle, but evidently takes part in spindle formation. He thus concludes that it is a veritable centrosome.

Strasburger, in his recent monograph (112) entitled "Ueber Reductionstheilung, Spindelbildung, Centrosomen, und Cilienbildner im Pflanzenreich," which appeared early in 1900, has again gone over the ground of swarm-spore and spermatozoid formation, and concludes that the blepharoplast of spermatogenous cells is distinct from a genuine centrosome or centrosphere, and traces its origin back to the "*Mundstelle*" of the swarm-spores of *Cladophora*, *Œdogonium*, etc., from which the cilia originate. His discussion of the matter is of the highest interest.

In 1900 the presence of spermatozoids in a third genus of the *Cycads* was proven. This was accomplished by Lang (77) in his investigation of *Stangeria paradoxa*. The spermatozoids in this instance have not yet been studied in the living state and the details of the spermatogenesis have not yet been followed.

In the report of a paper read before the American Society for Plant Morphology and Physiology, published in Science, February 15, 1901, the writer (128) described the cell division giving rise to the stalk cell and central cell, and the morphology of the prothallial apparatus which has been entirely misinterpreted in all previous descriptions. The description there given is the same as that published in this monograph.

ACKNOWLEDGMENTS.

In concluding the introduction, the writer desires to express his indebtedness to various friends for aid furnished in the course of this investigation: To Dr. William Trelease, director of the Missouri Botanical Garden, who kindly aided him by furnishing developing seeds of *Ginkgo biloba* collected at regular intervals, and by general advice; to Mrs. L. H. Webber for considerable aid in the preparation of drawings; to Prof. E. C. Jaffrey and Dr. Erwin F. Smith for aid in the preparation of photomicrographs; and to Sir William Dyer, Prof. B. L. Robinson, and Mr. F. V. Coville for the privilege of examining and studying the species of *Zamia* in the Kew, Gray, and U. S. National herbaria, respectively. Lastly thanks are due to my colleague, Mr. Walter T. Swingle, who has aided me greatly throughout this investigation. Whatever merit the study may possess is, in a large measure, due to him.

METHODS AND MATERIALS USED.

The investigations have been limited mainly to the species of *Zamia* growing wild in Florida. *Ginkgo* was studied somewhat for comparison, but as this plant was being studied by Dr. Hirase, little time was given to its investigation. When the writer began the investigation of *Zamia* the forms growing in Florida were all generally referred to *Zamia integrifolia* Jacq. In the course of the investigations it was found that there were at least two distinct species in the State, neither of which could be considered as belonging to *Zamia integrifolia* Jacq., which is a West Indian species. One species is found very abundant on the east coast of Florida south of New River. This corresponded well with the description of *Zamia floridana* D. C., and a comparison of a fragment of specimen and a tracing in the Kew Herbarium of De Candolle's original specimen showed that the south Florida form must undoubtedly be referred to this species.[1] It has large elliptical, strongly umbonate cones 6 to 8 inches long and about 2½ inches in diameter.

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[1] *Zamia floridana* D. C. (Prodromus 16, p. 544.) Leaves ovate or ovate-lanceolate, 20 to 30 cm. long, excluding the petiole; petiole about 20 cm. long, unarmed, triangular, sericeo-tomentose at base, with scattered hairs above; leaflets mostly opposite,

The other Florida species is found along the east coast of the State from Titusville north to St. Augustine. Its southernmost extension on the east coast of the State, so far as known, is about 150 miles north of the northernmost extension of *Zamia floridana*. The writer's study of this plant seems to indicate that it must be referred to *Zamia pumila* L.[1] Some doubt remains, however, in regard to this, and it may ultimately prove to be an undescribed form.

In 1893 the writer first began the collection and preservation of Zamia material in preparation for a study of the spermatogenesis and embryology. The investigation can hardly be said to have commenced, however, until the appearance in 1896-97 of Hirase's and Ikeno's preliminary papers announcing the occurrence of spermatozoids in *Ginkgo* and *Cycas*. A study of the spermatogenesis and phenomena of fecundation was then commenced and carried on as rapidly as possible.

It was found by experience that cones of the two species could be wrapped in paper and shipped a two days' journey without noticeable

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smooth above, with scattered hairs below, 14 to 20 pairs, linear, 9 to 14 cm. long and 3 to 7 mm. wide, falcate and somewhat twisted, approximately erect, 10 to 16 nerved, narrowed at base, apex obtuse, with five or six obscure dentations, margin revolute; mature pistillate cones, oblong, 12 to 16½ cm. long and 6 to 8 cm. in diameter, markedly umbonate, densely tomentose, with persistent dark brown hairs; peduncle ferrugineous, tomentose, short, about 10 cm. long; seed-bearing scales peltate, hexagonal, thick and somewhat hemispherical at outer end; staminate cones, oblong, dark brown, tomentose, about 8 cm. long and 2½ cm. in diameter; peduncles short, 5 to 10 cm. long. Very abundant in southern Florida on the east coast below New River (latitude about 26° 30′). Inhabits open, comparatively dry pine forests (flat woods). Included in *Z. integrifolia* by Gray and Chapman. Not *Z. integrifolia* Jacq.

[1] *Zamia pumila* L. (in part). Leaves ovate, exclusive of petiole 20 to 30 cm. long; petiole unarmed, about 20 cm. long, triangular, sericeo-tomentose at base and with scattered hairs above; leaflets mostly opposite, but frequently irregularly placed, smooth above and with scattered hairs below, 16 to 22 pairs, linear-lanceolate, somewhat falcate, 7 to 11 cm. long and 8 to 16 mm. wide, mostly straight, but occasionally slightly twisted, 20 to 28 nerved, narrowed at base; apex obtuse, slightly serrate, margin revolute; mature pistillate cones, elliptical, scarcely umbonate, 6½ to 10½ cm. long by 5 to 8 cm. in diameter, densely tomentose, with ferrugineous, somewhat deciduous hairs; seed-bearing scales peltate, hexagonal, thin, and somewhat flattened at outer end; peduncle ferrugineous, tomentose, short, about 10 cm. long; staminate cones, oblong, brown, tomentose, about 8 cm. long and 2½ cm. in diameter; peduncle short, about 5 to 10 cm. long. Abundant in central Florida, particularly on the east coast between latitudes 28° 30′ and 29° 30′. Inhabits mostly dense moist woods (hammocks).

Z. pumila differs mainly from *Z. floridana* in its shorter and broader leaflets, which are less twisted and not so erect and rigid, and in its shorter nonumbonate cones with seed-bearing scales thinner and more flattened at outer end. It, furthermore, is very distinct in range and character of habitat injury to the developing sexual organs. Arrangements were consequently made by which shipments of cones of the two species were received at regular intervals throughout the developing season. The cones of *Zamia floridana* were obtained at Miami, Fla. Two of these cones were mailed to the writer three times a week during the period found necessary to secure the desired stages. The cones of *Zamia pumila* were collected at New Smyrna and Daytona, Fla., and these were gathered and mailed to the writer twice a week, two or more being sent each time. In no case was the material injured in shipment so that any change in development could be observed. Cones remained fresh for a week or more after their receipt, and the normal process of pollen-tube development seemed to go on as usual until the seeds became very dry. This would normally be expected, as the developing pollen tubes derive their nutrition entirely from the nucellus, and the seeds are protected by their location, in the interior of the closed hairy cone, from any loss of moisture. All material fixed and utilized in the investigation was cut out and prepared immediately on the receipt of the cones, being taken thus about three days after the cones were cut from the plants. At several periods in the development visits were made to the regions where the plants grew, and absolutely fresh material was gathered and fixed in abundance for comparison. In all cases, however, material mailed to the writer gave results exactly the same as that cut and fixed in the field. In many cases cones were kept in the laboratory for one or two weeks after being received, and were examined at intervals to note how long they would remain satisfactory for study. In the examination of such cones the writer frequently found the spermatozoids living and moving in perfectly normal condition the same as those examined in the field a half hour after they were cut from the plant. The writer was located at Eustis, Fla., while the material was being shipped to him and prepared, but mail from Miami and New Smyrna required two days to make the journey, and could have been sent just as satisfactorily to Washington or New York. The facts regarding the shipment of the cones are given in some detail, as it is thought that *Zamia* should become a standard object of investigation and demonstration in the botanical laboratories of universities in the Eastern United States, and no trouble should be experienced in obtaining cones in good condition for study at any point within a three or even four days' railway journey of Miami, Fla., where abundant cones of *Zamia floridana* can be obtained. This is by far the best species for study, as a much larger percentage of the ovules are fecundated and a much larger number of pollen tubes are found developing in each ovule than in the case of *Z. pumila*. Further than this, the plants of *Zamia pumila* are more scattered, and it requires a considerable amount of work to secure any great number of cones. *Zamia floridana*, however, is very abundant at Miami, and almost an unlimited number of cones can be secured any season. The following statement of dates at which time important changes take place in the developing organs of *Zamia floridana* may be of service in guiding investigators in the securing of important stages for investigation. It must be remembered, however, that different plants vary considerably in their stages of development, and the dates are thus only approximate.

(1) Pollination takes place the last of December and first of January.

(2) Germination of pollen and growth of prothallial apparatus from January 1 to June 1.

(3) The division of the second prothallial cell, giving rise to the stalk cell and central cell, occurs February 15 to March 10.

(4) The blepharoplasts first appear about March 1 to 20.

(5) The gradual development of the central cell blepharoplasts and prothallial apparatus continues from March 1 to May 30.

(6) The prophase of division of the central cell appears about May 20 to 25.

(7) Spermatozoids mature mainly between June 1 and 15.

(8) Fecundation takes place mainly between June 1 and 15.

In *Zamia pumila* the date of maturing of the spermatozoids and of fecundation in 1897 was fully three weeks later than in *Z. floridana*, and it is probable that this species is ordinarily considerably later. On the other hand, the date of maturity of the male cones, the pollination, and the first appearance of the blepharoplasts in the two species was found to be about the same.

When the cones were received the seeds were cut out and a portion of the apex of the nucellus 3 to 4 mm. in diameter, which contained the developing pollen tubes, was transferred as quickly as possible to the fixing solutions. In preparing the archegonia for study, cylinders about 5 mm. long and 2½ or 3 mm. in diameter were cut out of the apical portion of the prothallus containing the archegonia, and transferred to the fixing solution. Quite large portions of tissue must be used in this case from necessity, as the egg cells if cut into are destroyed for study, the protoplasm flowing out. In some cases portions of the seed were cut out and prepared, with the nucellus and prothallus in connection, to show the apparatus *in situ*, but this method is not satisfactory for the study of the finer cytological details of structure.

Various fixing agents were used in the course of the work, including Flemming's chromic-aceto-osmic acid solution, weak and strong, Hermann's platino-aceto-osmic acid solution, Van Rath's solutions II, III, and IV, chromic acid one-half per cent and 1 per cent, etc. Flemming's strong solution was used more than any of the other fixatives, and gave in general the best results. Its time of action was varied considerably, and in probably the majority of cases it was used diluted somewhat with water in the ratio of one part of the strong solution to two, four, nine, or nineteen parts of water. In general, a solution of one part to four parts water gave very excellent results in fixing the pollen tube apparatus. In the fixation of the archegonia, however, at the time of fecundation and during the development of the embryos, it is necessary to use the fixative very strong, as it is difficult for the solution to penetrate the starchy matter of the prothallus which surrounds the archegonia.

In staining, the Flemming triple process with safranin, gentian violet, and orange G. gave by far the best results and was most extensively used. Heidenhain's iron-hæmatoxylin was also used considerably, and besides this Czoker's alum cochineal with Bismarck brown, fuchsin, and some other stains were occasionally used for comparison.

DEVELOPMENT OF THE MICROSPORES.

The pollen cones (figs. 3 and 4) of the two Florida species of *Zamia* begin to appear at the apex of the stem in July and continue to develop until the following January, when the pollen is discharged and pollination takes place.

The mature pollen grain examined in water is nearly spherical, but somewhat flattened on one side where the prothallial apparatus is attached. (Fig. 11.)

The earliest description of the pollen of *Zamia* known to the writer is that of Schacht (97) in 1860:

> Endlich hat Zamia ein kleines Pollenkorn mit einer sehr tiefen Längsfalte, welche sich in Wasser nicht ausgleicht. (Taf. XVII, F. 26 und 27.) Dieser Falte gegenüber liegt die kleine Tochterzelle, welche erst bei sehr gelungenen Querschnitten sichtbar wird (F. 28) und wahrscheinlich wie bei Cupressus nicht zur Ausbildung kommt, während die grössere sich als Pollenschlauch verlängert.

In 1872 Juranyi (72) described the structure and development of the pollen of *Ceratozamia longifolia*, which evidently corresponds closely with what occurs in *Zamia*. He found that two small cells were regularly cut off at one side of the large cell, and in some cases three. While the different cell stages of development are described and figured, the details of the division leading to the formation of the differferent cells was not followed.

In his study of the development of the pollen of certain Cycads, principally *Ceratozamia mexicana*, Guignard (45) was unable to confirm Juranyi's conclusion as to the occasional production of three prothallial cells. "According to the observations of M. Juranyi," wrote Guignard, "a third small cell may be formed by the division of this latter nucleus; but it does not appear to be so in the case of *Ceratozamia mexicana*."[1]

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[1] "D'après les observations de M. Juranyi" wrote Guignard, "il peut se faire une troisième petite cellule, par suite de la division de ce dernier noyau; mais il ne paraît pas en être ainsi dans le *Ceratozamia mexicana*."

In the formation of the two prothallial cells, Guignard shows that in each case it is the nucleus of the large cell which divides in cutting off the small cells of the prothallus.

In the species of *Zamia* studied by the writer, the mature pollen grain always shows two prothallial cells cut off at one side, and protruding into it (fig. 11). The development of the pollen has not been carefully studied, and the details of the formation of the prothallial cells is not known. It seems from the writer's observation, however, that three cells are at least occasionally formed: and in this case the first one cut off is resorbed, as described by Strasburger (109) and others in *Pinus*, *Ginkgo*, etc., remaining as a dark more or less refractive layer in the wall of the pollen grain situated at the point of contact of the other cells (figs. 11, 13, and 14). In many instances of mature pollen grains, and in later stages, during germination, no indication of this resorbed prothallial cell can be observed, but in some cases it may be seen very plainly, and is unmistakable.

In *Ginkgo*, according to Strasburger (109) and Hirase (62), the nucleus of the pollen grain undergoes normally three divisions, by which three prothallial cells are cut off, the first of which becomes compressed against the wall of the pollen tube and is largely resorbed, in the mature pollen grain appearing very indistinctly as a slight layer in the wall (Strasburger, 109, Pl. I, figs. 5 to 7, and Hirase, 62, fig. 1).

A careful investigation of the development of the pollen of *Zamia* will have to be made before it can be determined whether three prothallial cells are regularly formed or whether the remnants of a third cell, occasionally observed, are to be considered as cases of rare and somewhat abnormal development. Judging from the normal occurrence of three cells in *Ginkgo* and *Pinus*, it would seem that probably three cells may also be normally formed in *Zamia*. However, in the mature pollen grain, and in the pollen grains after germination in the nucellus, a third cell can only occasionally be observed, and the description here given will deal mainly with the two prothallial cells plainly evident in all cases.

The nomenclature used here for the various cells of the antheridium is somewhat different from that usually used. It was thought best to use terms more in harmony with those used in the Pteridophytes in order to avoid confusion. The two prothallial cells normally cut off in the pollen grain are distinguished in the order of their formation as the first and second prothallial cells (P1 and P2). When the second prothallial cell divides it gives rise to the stalk cell and central cell (Körper cell, body cell, generative cell, etc.). The cell here called the central cell is considered by Strasburger (109, p. 7) and others as corresponding to the central cell of the antheridium in ferns. The central cell when it divides gives rise to the spermatids, which become metamorphosed directly into spermatozoids. The entire apparatus, including the stalk cell and central cell (Körperzelle or generative cell) is spoken of throughout as the male prothallus, or simply prothallus where it is not necessary to distinguish more closely. The nomenclature here given corresponds with that used by Shaw in *Marsilia* (102).

In the case of *Ginkgo*, judging from Strasburger's and Hirase's figures, the walls of the prothallial cells cut off extend comparatively straight across the pollen grain, in each cell the new wall as formed being attached to that of the pollen grain. In *Zamia* quite a different form is found. Here the cells arch out into the tube cell of the pollen grain (fig. 11). In none of these cells is a cellulose wall laid down, there being nothing but a plasma membrane or hautschicht formed. The first prothallial cell is shaped like a plano-convex lens and arches out into the second prothallial cell. In the mature pollen grains it can not be determined whether the plasma membrane formed in cutting off this cell is attached at the sides to the plasma membrane of the tube cell, as must be the case if only two prothallial cells are formed, or to that of a third resorbed prothallial cell. In some cases of germinating pollen grains where the prothallial apparatus has developed considerably and where remnants of a resorbed third prothallial cell can be observed, the attachment would seem to be to the plasma membrane of this cell (figs. 13 and 14). This would also be indicated by Juranyi's figures of *Ceratozamia* (72, Taf. 33, figs. 8–11).

The second prothallial cell is attached to the first prothallial cell and arches out into the tube cell. Its membrane is connected only with that of the first prothallial cell. This cell, while the most important and ultimately much the largest, is in the mature pollen grain considerably smaller than the first prothallial cell. The protoplasm of the prothallial cells is densely granular and the nuclei, which nearly fill the cells, are difficult to distinguish. The nucleus of the tube cell is much larger than the nuclei of either of the prothallial cells and is situated at the apex of the prothallus.

The mature pollen grain of *Cycas revoluta*, as shown by Ikeno (70, Pl. VIII, fig. 13), would seem to be considerably different from *Zamia*, in that the cell membrane of the prothallial cell extends straight across the grain, as figured by Strasburger and Hirase in *Ginkgo*, instead of arching out into the tube cell as in *Zamia*. The structure described by the writer in *Zamia* is the same as that described by Juranyi (72) and Guignard (45) as occurring in *Macrozamia*.

Pollination in both of the species of *Zamia* studied apparently takes place in the latter part of December and first of January, and is accomplished mainly through the agency of the wind. The pollen is produced in great abundance and is light and easily carried. The scales of the female cones throughout their existence, except at the time of pollination, are tightly closed, so that no dust can gain admission to the interior (figs. 2 and 6). When the cone is receptive and ready for pollination the basal scales of the cone separate from those above, leaving a crack about one-eighth to one-fourth of an inch wide between them. This crack extends around the entire base of the cone and apparently remains open at least a day or more, though the time has not been determined by actual observation. When the ovules are pollinated, apparently the row of scales immediately above this move downward, closing the original crack and leaving a similar opening between them and the row of scales next above. This process evidently continues in succession, following the spiral arrangement of the scales, until the top is reached and all of the ovules have been pollinated. Several days are evidently consumed in the process of pollination of a single cone. The scales evidently reverse in quite regular order, as the opening between them is never found here and there over the cone, but always in a continuous and quite regular crack running around the cone. A single scale does not remain open longer than others because its ovules have not been pollinated, as might be supposed from the fact that almost universally among plants the style of a pistil which has not been pollinated remains fresh and the stigma receptive, and persists for a much longer period than in one which has been pollinated. The effect of pollination in *Zamia* seems to have no influence on the length of time during which the scales remain open or on their endurance. The writer has found many cones developing normally for several months after pollination in which only a few seeds had set, and frequently mature cones have been found containing only two or three seeds. This infertility is doubtless due to the lack of pollination, as it has only been found in the case of *Z. pumila* at New Smyrna and Daytona, where microscopic examination has revealed a decided lack of pollen, many ovules being frequently found in a cone without a trace of pollen or pollen tubes. The plants of this species in these regions are scattering and pollination is frequently very imperfect.

Z. floridana in the regions studied is very fertile, almost every ovule being fecundated and maturing a perfect seed.

DEVELOPMENT OF PISTILLATE CONES.

In the present paper the structure and development of the pistillate cones (figs. 2 and 6) will be discussed only so far as it bears on the question of development of the pollen tubes and fecundation. At a later time the writer hopes to describe the development of the archegonia more in detail.

At the time of pollination the ovules are about 1 cm. long by 5 mm. broad (fig. 2). The single coat of the naked ovule is considerably thickened at the apex, and the micropyle through which the entire pollen grain must pass forms a continuous tube from the surface to the apex of the nucleus, a distance of about 3 mm. The micropyle at the apex of the ovule may be seen with the unaided eye as a small round hole somewhat smaller than the diameter of an ordinary pin—about one-fourth millimeter (figs. 1 and 9).

The nucellus at this time is about 2 mm. in diameter and pointed at the apex. Shortly before pollination the tissue at the apex of the nucellus was found to be solid entirely to the point; but just before or during pollination a cavity, the pollen chamber for the reception of the pollen, is formed in the apex by the breaking down of the tissue (fig. 5). The pollen grain to be effective must pass through the entire length of the micropyle and finally come to lie in this chamber. It is difficult to understand how the nonmotile pollen grains can ever reach the pollen chamber, which would seem to be absolutely safe from infection by them. It is easy, however, to see how a few grains may be wafted by the wind into the cone, when the scales separate as above described, and rattle down to the axis of the cone, around which the apexes of the ovules are crowded.

The passage of the pollen grain through the micropyle is evidently accomplished by suction. A mucilaginous, stigmatic, or micropylar fluid is secreted by cells of the ovule coat surrounding the micropyle, and this is evidently protruded in a drop from the micropyle at the time of pollination as a trap for the pollen. This secretion has at least been observed several times by the writer protruding from the opening of the micropyle at about the time of pollination, and its formation is thought to be of normal occurrence. This secretion later disappears, and a suction is probably formed by the breaking down of the cells in the formation of the pollen chamber which leads to the fluid, together with any pollen grains which have come in contact with it, being drawn down into the required position in the pollen chamber. The gradual absorption of the fluid by the cells of the nucellus bordering the pollen chamber would, of course, accomplish the same result. The breaking down of the tissue at the apex of the nucellus in the formation of the pollen chamber occurring about this time would seem to have some significance of this sort, and is believed by the writer to unquestionably be connected in some such way as above described in securing the passage of the pollen grains to the nucellus. In reaching the entrance to the micropyle of the ovule the pollen grains largely follow the trend of gravity. The passage of the micropyle, however, which is but slightly larger in diameter than the pollen grains, must be made against the action of gravity, and some such explanation as the above is necessary to understand how it can be accomplished. In *Ginkgo* and *Cycas* the pollen must pass through a similar long and narrow micropyle, and some such method of pollination must occur.

At the time of pollination in January the prothallus forms a spherical mass of soft, watery, rapidly-developing tissues in the middle of the nucellus which still comprises a considerable thickness of tissue on each side (fig. 1). No trace of the archegonia can yet be discovered.

The ovule at this time has reached only about one-third of its mature width and length, and growth in the size of all organs continues for a considerable period following pollination. The prothallus grows in size proportionately more rapidly than the other organs, and this is accomplished largely at the expense of the nucellus, which gradually becomes thinner throughout, and is finally, at the time fecundation occurs, found to be compressed to a very thin membrane at the apex, and below on the sides and base has largely split up into very thin shreds, seldom being found as an unbroken membrane throughout.

The archegonia are differentiated in the upper part of the prothallus shortly after pollination, but do not reach their mature size until a short time before fecundation, which does not occur until four months later. Four archegonia are almost universally formed in each prothallus, but some instances have been observed where a fewer (2 or 3) or a larger number (5 or 6) have been developed.

During the increase in size of the archegonium through the months of March, April, and a part of May, the nucleus of the central cell remains in the upper part of the cell near its point of reorganization after the preceding division, which gave rise to the neck cell (fig. 10). It is usually elliptical and very large in comparison with the nuclei of surrounding cells. This location of the nucleus during the main growth period of the central cell of the archegonium is evidently common in related plants until after the ventral canal cell is cut off. Treub described the same location in *Cycas circinalis* (117), Ikeno in *Cycas revoluta* (65), Hirase in *Ginkgo* (59), Blackman in *Pinus sylvestris* (16), and Murrill in *Tsuga canadensis* (91, p. 587).

The protoplasm of the central cell during the latter part of this period of growth in size presents the most beautiful foam structure the writer has ever observed.

Shortly before fecundation the nucleus of the central cell divides and a small cell is cut off at the apex, which corresponds to the ventral canal cell of the conifers. Until the publication of Ikeno's preliminary note announcing the discovery of this canal cell in *Cycas revoluta* (65) it had been supposed that it was not formed in the Cycadaceæ. It would seem, however, from its occurrence in *Cycas* and *Zamia* that it is probably as generally formed in the Cycadaceæ as in the Coniferæ. Hirase has also recently described the formation of this cell in *Ginkgo biloba* (59).

The writer has not observed the division of the nucleus leading to the formation of the canal cell in *Zamia*, but the process probably corresponds very closely to that occurring in *Cycas*, *Ginkgo*, and the Coniferæ. The nucleus of the central cell in preparing for division evidently goes through changes similar to those described by Murrill in *Tsuga canadensis*, and it would be interesting to know if the same unique method of spindle formation occurs in *Zamia* also. The accumulation of highly granular cytoplasm in a conspicuous mass below the nucleus of the central cell, as described by Murrill in *Tsuga*, is uniformly found in stages immediately preceding division in *Zamia*. The synapsis condition observed by Murrill in an early prophase of the division in *Tsuga* is also of common if not normal occurrence in *Zamia*, so that it would seem probable that the spindle formation in *Zamia* may be similar to that of *Tsuga*. It is interesting to observe that the spindle formed in this division is strikingly blunt-poled, as observed by Ikeno in *Cycas* (65) and Blackman in *Pinus* (16).

Before fecundation the canal cell breaks up and loses its identity, only traces of it being occasionally found at the time of fecundation. After the division giving rise to the canal cell is completed, the lower nucleus which forms the oosphere travels from the apex of the cell downward toward the center and takes a position slightly below the middle of the cell, where it remains until fecundation takes place. It is usually spherical or slightly elliptical, and its contents are much less dense than the surrounding cytoplasm of the egg cell, with which it forms a marked contrast. The mature egg cell is usually elliptical or slightly reniform and is about 3 mm. in length and from 1 to 1.5 mm. in width. The nucleus is very large, being about 553 μ long and 467 μ in diameter. It is plainly visible to the unaided eye in stained sections and it is hard to realize on looking through a section held up to the light that one is viewing the egg cell and its nucleus without even the use of a hand lens.

In the development of the prothallus a circular depression known as the archegonial chamber (prothallial or endosperm cavity) is formed in the upper part of the prothallus immediately above the archegonia and beneath the apex of the nucellus (fig. 9).

This cavity is usually about 2 millimeters in diameter and a millimeter deep. It is into this cavity that the pollen tubes later grow and discharge their spermatozoids. The openings to the four archegonia can be seen easily in the bottom of the cavity, the two neck cells being turgid, hyaline, and quite distinct in appearance from the surrounding cells of the prothallus. They protrude above the general surface and appear to be under considerable tension.

DEVELOPMENT OF THE POLLEN TUBE AND PROTHALLUS.

GERMINATION OF POLLEN AND GROWTH OF PROTHALLUS.

Very shortly after the pollen grains have been drawn down into the pollen chamber of the nucellus they germinate, the tube, which at first is about the diameter of the pollen grain or slightly less, bursting out of the exine of the grain at a point opposite the attachment of the prothallus. No matter in what direction the pollen grain may lie, the tube as soon as protruded grows toward the tissue of the nucellus, forming the side of the pollen chamber, into which it soon penetrates (fig. 5).

If the pollen grain is so situated that the tube when first protruded points toward the apex or base of the nucellus, it makes a sharp turn immediately after leaving the pollen grain and enters the nucellar tissue. In *Zamia* the tube never branches before entering the tissue, and while it occasionally branches after entering the tissue, this is by no means of common occurrence. The majority of tubes remain unbranched throughout their growth. In *Gingko*, on the contrary, the distal end of the tube as soon as it enters the nucellar tissue becomes very much branched and the ramifications are so slender that it is only with the greatest difficulty that they can be traced.

When the pollen tube first ruptures the exine and protrudes, it is considerably smaller than the diameter of the pollen grain. The relation of the prothallial cells and tube cell which forms the tube is shown in this stage in figure 12. As the tube pushes out, the protoplasm of the tube cell draws away from the wall of the old pollen grain to some extent apparently in all instances, though it would seem probable that the contraction shown in the figure is somewhat abnormal. The nucleus of the tube cell, which is densely granular, immediately passes into the tube, becoming the pollen tube nucleus, and travels farther as the tube grows, remaining always about a uniform distance from the apex of the tube. In this early stage of germination the cells of the prothallus have the same size as in the mature pollen grain and appear about the same.

The entire prothallus in this stage is about 9 μ wide and 8 μ long (length being considered the extension in the direction of the growth of the pollen tube). The nuclei in both the first and second prothallial cells are still very densely granular and almost fill up the entire cell in each case. The nuclei in both cells are more or less crescent-shaped in median section, corresponding to the shape of the cells. In the tube shown in figure 10 the nucleus of the first prothallial cell measured 7.12 by 3 μ; that of the second prothallial cell 8 by 3 μ, and the nucleus of the tube cell 8.01 by 5.34 μ, the nucleus of the tube cell in this stage always being slightly larger than the nuclei of either of the prothallial cells.

When the Flemming triple stain was used in the study of pollen tubes the safranin always stained the wall of the pollen grain red, serving as an important distinction for a pollen grain wall throughout the development of the apparatus.

Before the pollen tube has increased in length very greatly it increases also noticeably in width, and by the time it has reached a length four or five times as great as the diameter of the pollen grain it has reached a diameter as great as that of the pollen grain (fig. 13). The point where the tube bursts out of the pollen grain has also enlarged, the broken edges of the exine being bent outward. Meanwhile the tube nucleus has assumed a round form, increasing somewhat in size.

The protoplasm presents a beautiful foam structure, with large vacuoles here and there. The starch grains which later fill the tube have not yet begun to appear.

The next noticeable differentiation in the growth of the tube is the increase in size of the cells of the prothallus. Both cells increase in width and length and the first prothallial cell pushes out into the second prothallial cell, which becomes shaped like a concavo-convex lens and is crescent-shaped in cross section. Figure 14 shows a pollen tube in the first stage of the development of the prothallus. The prothallus here has reached a size of 15 μ wide by 16 μ long. The nuclei of both prothallial cells have increased slightly in size and become spherical and less densely granular. The pollen tube is meanwhile gradually growing in length and diameter, the tube nucleus passing farther down as the tube elongates. In this tube (fig. 14) a dark line appears at the base of the prothallus which seems undoubtedly to be the remains of a third prothallial cell which has been resorbed.

The pushing out of the first prothallial cell into the second prothallial cell is a point of considerable interest in clearing up the morphology of the prothallial apparatus, which was left in a very unsatisfactory state in the writer's preliminary papers, as well as in the papers of Ikeno (70) and Hirase (62). In a somewhat later stage, when both of the prothallial cells have reached almost twice the size described in the last-mentioned stage, the first prothallial cell can be seen to have pushed a considerable distance into the second prothallial cell, the point of attachment of the plasma membrane of the cells still remaining in about the same relative position as in the original pollen grain (fig. 15). Meanwhile the second prothallial cell has arched out still farther, and by the increase in size of the first prothallial cell has been carried mainly out of the old walls of the pollen grain into the pollen tube. It may be remarked here that the prothallus still retains its original connection with the wall of the pollen grain, a connection which remains unbroken until the spermatozoids mature. In the preceding stage the nucleus of the second prothallial cell had increased in size slightly more rapidly than that of the first prothallial cell and had become slightly larger (fig. 14). In this stage (fig. 15) the second prothallial cell nucleus has become decidedly larger than that of the first prothallial cell.

DIVISION OF SECOND PROTHALLIAL CELL.

Shortly after this stage the second prothallial cell divides into two very unequal cells, the stalk cell and central cell (körper cell, generative cell, etc.). In his early studies the writer concluded from analogy with the development of the gymnosperms as described by Belajeff (2 and 3), Strasburger (109), and others, that a division of the second prothallial cell must take place. It, however, was only after prolonged and diligent search that the evidence establishing this fact was finally secured, and only a single tube has been found in all the many examined where the presence of a division was evident. This, however, was fortunately in just the stage to settle the disputed point. It is in a telophase of the division when the two-daughter nuclei are reorganizing and the spindle connecting them is yet clearly evident (fig. 17). The first prothallial cell extending into the second prothallial cell is here clearly distinguishable, as in the preceding case described (fig. 15). The spindle, from the crescent shape of the second prothallial cell, assumes a position at an angle to the major axis of the prothallus, the lower nucleus and end of the spindle being crowded to one side by the position of the first prothallial cell, while the upper nucleus occupies a central position in the upper half of the cell which, when the new wall is formed, will become the central cell. The lower nucleus, which becomes the nucleus of the stalk cell, is already in this early stage noticeably smaller than the upper nucleus. Several round bodies which take a brilliant safranin stain in the Flemming triple process, and are evidently masses of nucleolar matter, are situated in the cytoplasm just outside of the spindle. The reorganizing daughter nuclei, in the only section secured in this stage, are too densely stained to show their structure well; they appear simply to be densely granular. The spindle fibers show very plainly, but do not as yet show any thickenings in the center preparatory to the formation of a cell membrane. A most careful search has failed to reveal any suggestions of a centrosphere or centrosome at the apex of the spindle where one might be expected to occur. In a number of instances a careful search has been made in the second prothallial cell, when it approaches division, for evidence of the presence of organs resembling blepharoplasts or centrosomes. Occasionally small centers with a few radiations have been observed (fig. 16), but these are irregular in their appearance and would seem to have no relation to blepharoplasts or centrosomes. The pollen tube at this time has reached a length of over 1 millimeter and starch grains have begun to appear, two being shown in the tube figured. Cells in the path of the tube are broken down and absorbed, apparently very little or no trace of them remaining.

In *Z. floridana* in 1898 the division of the second prothallial cell was found to take place mainly between February 15 and March 5. In *Z. pumila* the same year the corresponding division occurred between February 25 and March 15.

In a stage but slightly later than the above the central and stalk cells are found to be separated by a plainly visible plasma membrane thrown across the cell just above the apex of the first prothallial cell (fig. 18). This stage is a very easy one to find and the writer has many sections showing it very plainly. In the tube shown in figure 18, which is only shortly after the completion of the division, the nuclei of both the stalk and central cells have assumed a rounded form, the latter being much the larger. The nucleus of the central cell is here 9.79 μ in diameter while that of the stalk cell is only 7.12 μ and that of the first prothallial cell about 8.9 μ in diameter. The entire prothallus in this stage immediately after the division is only 29.37 μ long by 16.91 μ wide. The first prothallial cell is now almost entirely surrounded by the stalk cell, only the base of the cell remaining in its original position. A few small starch grains have already begun to appear in this cell, two being shown in the figure. In later stages both this cell and the stalk cell become crowded with starch. Before proceeding farther it will be desirable to point out the views held in regard to the structure of the prothallus in Cycadaceæ and *Ginkgo* in previous publications. Attention was first called to the peculiar structure of the prothallus in the Cycadaceæ in the writer's first preliminary paper on *Zamia* (122). Here it was stated:

> The former cell [in reality the stalk cell, as proved by later researches] is spherical or slightly elongated and presents a most singular structure. The nucleus of the original cell evidently divides into two, and one of the daughter nuclei forms within the unbroken *Hautschicht* of the mother cell a new and wholly distinct *Hautschicht*, which delimits a cell lying entirely free within the mother cell and surrounded on all sides by a layer of protoplasm of nearly uniform thickness (figs. 1a and 2). The other daughter nucleus remains free within the *Hautschicht* of the mother cell, but is pressed to one side by the interior cell.

It will be seen from this that the writer was greatly in error in his early interpretation. This was largely due to the fact that sections must be exactly median longitudinal through the pollen grain and prothallial apparatus to show that the first prothallial cell (interior cell) has any connection with the wall of the pollen tube. Cross sections of the tube which were then used considerably in the writer's investigations also fail to show the true relationship of these cells. Their confusing structure in a section of this kind will be seen by examining figure 23. The difficulty of the investigation leading to the correct interpretation of this structure is also shown by the views expressed by the Japanese authors which are at great variance with those of the writer.

In *Ginkgo* the first prothallial cell, which the writer has found to become surrounded by the stalk cell through transformation during growth, Hirase considers to be simply strands of protoplasm in the second prothallial cell. He says:

> At the extremity of the tube, which is covered by the exine and extends into the cavity, are found in the interior two flattened prothallial cells which are now separated from each other. Between these there are large vacuoles, and it may be seen also that they are united by the cytoplasm which forms two hollow cylinders placed one within the other, so that if a section be made along the longitudinal

axis of a pollen tube appearing at this stage, the two cells appear to be joined together by four cytoplasmic filaments. This condition of the tube continues up to the moment of fecundation.[1]

In the further development of the prothallium Hirase states that the second prothallial cell divides, and without forming a partition wall one of the naked nuclei is crowded out of the cell into the first prothallial cell, coming to be located outside of the interior protoplasmic strands. He says:

> In the middle of July the nucleus of the interior cell [second prothallial cell] above mentioned divides into two daughter nuclei. I have not had an opportunity to observe the karyokinesis of this division * * * . Immediately after their division, one of the nuclei becomes much larger than the other and proceeds to occupy the central part of the mother cell, increasing in size more and more. On the other hand, the smaller of the two daughter nuclei leaves the mother cell, or, rather, is expelled from it by the other, and proceeds as far as the space between the two cytoplasmic cylinders which connect the mother cell with the posterior prothallial cell.[2]

The naked nucleus which after the division of the second prothallial cell is crowded out of this cell into the first prothallial cell he considers to be the equivalent of the stalk cell or *stielzelle* of the Coniferæ, and the cell from which it is expelled he says corresponds to the *Körperzelle* (central cell).

Ikeno's description of the development of this stage in Cycas (70, p. 570) corresponds in all important points with that given by Hirase for Ginkgo. He wrote:

> While the latter cell [second prothallial cell] has become somewhat extended and is still globular, its nucleus divides into two daughter nuclei of equal size. * * * A septum between these daughter nuclei is never formed. One of them only expands rapidly and occupies the larger space of the mother cell, so that the other cell is immediately expelled from it in a naked state.[3]

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[1] À l'extrémité du tube qui est couverte par l'exine et fait saillie dans la cavité, on trouve à l'intérieur deux cellules prothalliennes aplaties qui sont maintenant séparées l'une de l'autre. Entre elles, sont de grandes vacuoles et on voit aussi qu'elles sont unies par le cytoplasme qui forme deux cylindres creux placés l'un dans l'autre, de sorte que si l'on coupe selon son axe longitudinal un tube pollinique parvenu à ce stade les deux cellules semblent être réunies ensemble par quatre filaments cytoplasmiques. Cet état du tube persiste jusqu' au moment de la fécondation. (62, p. 109.)

[2] Au milieu de juillet, le nucléus de la cellule intérieure [second prothallial cell] susdite se partage en deux nucléus-fils. Je n'ai pas eu la chance de pouvoir observer la karyokinèse de cette division * * * . Aussitôt après leur formation, l'un des nucléus devient beaucoup plus gros que l'autre et vient occuper la partie centrale de la cellule-mère en grossissant de plus en plus. Au contraire, le plus petit des deux nucléus-fils quitte la cellule-mère ou mieux en est refoulé par le plus grand et s'achemine jusqu'à l'espace compris entre les deux cylindres cytoplasmiques qui joignent la cellule-mère et la cellule prothallienne postérieurs (62, p. 110).

[3] Während die letztere Zelle [second prothallial cell] etwas ausgewachsen ist und noch kugelig bleibt, theilt sich ihr Zellkern zu je zwei Tochterkernen von gleicher Grösse. * * * Eine Scheidewand zwischen diesen Tochterkernen wird niemals gebildet. Einer von ihnen nur wächst schnell aus und nimmt den grösseren Raumtheil der Mutterzelle ein, so dass der andere alsbald im nackten Zustande aus ihr verdrängt wird.

Ikeno also considers the naked nucleus expelled to be the homologue of the Stielzelle or stalk cell and the cell from which it was expelled the homologue of the Körperzelle. It does not appear from Ikeno's monograph that he observed the division of the third prothallial cell leading to the formation of this structure. Judging from his short description and indefinite figures it would seem that his material at this stage must have been poor or lacking. In none of his figures of the male prothallus does he show an interior cell like the writer's first prothallial cell or strands of protoplasm such as Hirase describes in *Ginkgo.*

The two nuclei in his "first prothallial cell" are in position exactly the same as the corresponding nuclei in *Zamia* and *Ginkgo*, but no strands of protoplasm or cell membrane separates them. The "Körperzelle" in his figures 15 to 19a is indicated as entirely spherical and not influenced in shape at the attachment with the prothallial cell, which seems very unlikely. The writer is unable to suggest how this apparent difference between *Cycas* and *Zamia* can be explained. The series of *Zamia* preparations on which his interpretation is based has been shown to several American botanists, and they entirely concur with him as to the structure of *Zamia.*

The development of the prothallial apparatus of both *Zamia* and *Ginkgo* has been studied by the writer with considerable care at different times during a period of nearly four years, and with abundant material at different stages. The interpretation given by Hirase and Ikeno seemed so novel and improbable that he was stimulated to a more thorough investigation. The early studies of Juranyi (72), etc., give no aid in this question, as in his study of *Macrozamia* he germinated and grew the pollen on soft pieces of pear fruit, and it has been amply demonstrated since, that the developments obtained in this way were abnormal. Juranyi obtained fairly long tubes developed from the large pollen cell, traced the nucleus in its passage into this tube, and in two instances found that this nucleus had divided into two. The so-called Innenkörper (the prothallus), however, remained in its place, decreased in size as the tube elongated, and finally disappeared. Strasburger (110) cultivated pollen of *Ceratozamia* in the same way, and found that the Innenkörper did not disappear as long as the tubes remained in apparently a normal healthy condition. Belajeff (2 and 3) was the first investigator to introduce the only safe method, that of studying the pollen tubes developed on the pistil in the normal way, by sections of the pistil and isolating the tubes by maceration methods. His study of gymnosperms, however, did not extend to any of the *Cycadaceæ.*

In 1892 Strasburger described the development of the pollen and pollen tube of *Ginkgo*, but was led to erroneous conclusions, apparently, by the insufficiency of his material. He correctly described and figured the pollen tube and prothallus in an early stage still showing the two prothallial cells in position. In describing the further development, however, he says:

> It is thus shown that in the second half of September the first of the two prothallial cells divides into a body cell and a stalk cell, while the outer prothallial cell usually remains undivided. The body cell corresponds to the central cell of an antheridium; it increases in size more than double, and its nucleus is enlarged in the same proportion. Hereupon this central cell undergoes commonly a cross or oblique division, by means of which two generative cells are created. The stalk cell of the antheridium is divided apparently only under certain conditions. Then the stalk cell and the first prothallial cell lose their independence, and the liberated generative cell passes into the pollen tube.[1]

This method of development would make *Ginkgo* correspond nicely with what occurs in some of the Coniferæ, but would seem to be quite different from what actually occurs in *Ginkgo*.

The writer's investigation of *Ginkgo*, so far as carried out, indicates that the development of the prothallus here corresponds entirely with that described above in *Zamia*. Shortly after germination the first and second prothallial cells can be discovered in the process of extension, the first protruding considerably into the second. In *Ginkgo* the writer has not been fortunate enough to find the division of the second prothallial cell, which gives rise to the stalk cell and central cell. The three-celled stage immediately following the division, however, compares almost exactly with the three-celled stage of *Zamia* (compare figs. 15 and 18), showing the first prothallial cell protruding into the stalk cell, and almost entirely surrounded by it. In older stages, both in *Ginkgo* and *Zamia*, when the central cell approaches the time for division, the first prothallial cell is almost invariably found to have grown up within the stalk cell to such an extent that it comes in contact with the central cell (fig. 20). In *Zamia* several instances have been observed where it has even caused a decided indentation in the central cell (fig. 22). Another feature of importance in showing that what the writer calls the first prothallial cell is a genuine cell and not simply a central portion of a cell inclosed by protoplasmic strands is shown in the fact that, in some cells as a result of fixation or a different stage of development, the plasma membranes or *Hautschichts* of the two adjoining cells separate, so that one can clearly distinguish two distinct membranes (fig. 19). The plasma membrane delimiting the cells in this case stain the same and appear the same in all noticeable characters as the membranes in other portions of the same cell and of the central cell.

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[1] So zeigt es sich denn, dass in der zweiten Hälfte des Septembers die vordere der beiden Prothalliumzellen in eine Körperzelle und eine Stielzelle zerfällt, während die äussere Prothalliumzelle gewöhnlich ungetheilt bleibt. Die Körperzelle entspricht der Centralzelle eines Antheridiums, sie schwillt zum mehr als Doppelten noch an, und in demselben Maasse vergrössert sich ihr Zellkern. Hierauf erfährt diese Centralzelle schon vielfach eine quere oder schräge Theilung, wodurch zwei generative Zellen geschaffen werden. Die Stielzelle des antheridiums scheint sich nur unter Umständen zu theilen. Dann geben Stielzelle und erste Prothalliumzelle ihre Selbständigkeit auf, und die befreite generative Zelle wandert in den Pollenschlauch ein. (109, p. 18).

APPEARANCE AND GROWTH OF BLEPHAROPLASTS.

After the division of the second prothallial cell into the stalk cell and central cell the entire apparatus continues to grow in size, and the next important stage of development following this is the appearance of the blepharoplasts.[1]

In order to determine the true nature of the blepharoplast it was necessary to know its history, and a very careful study has been made of its first appearance and gradual development. They were first discovered by the writer in *Zamia* in a medium stage of development, as shown in figures 26 and 58, in which stage they present a very striking appearance and would be taken for undoubted centrosomes. Similar organs occur in the central cell of *Ginkgo biloba*, and were first described by Hirase in 1894 (57). Hirase simply described their appearance in a half-grown stage, without tracing out their origin and function. They were next described by the writer in *Zamia* in 1897 (122, 123, and 124), and here their gradual growth and development into the cilia-bearing organ of the spermatozoid was traced. It was further found that they had no intimate connection with fecundation, being left at the apex of the egg cell while the nucleus passes on alone and fuses with the egg nucleus.

Not being able to obtain material of *Zamia* in 1897 to trace out the origin of the blepharoplasts, the early stages of *Ginkgo* were studied, and it was found that here they were formed *de novo* in the cytoplasm of the central cell. In 1898 the same organs in *Cycas revoluta* were carefully described by Ikeno (70). Since publishing his results in 1897 the writer has made a very careful study of the early stages in *Zamia*, and finds that here also they originate *de novo* in the cytoplasm of the cell, as first described by him in *Ginkgo*.

During the division of the second prothallial cell as pointed out above (fig. 17), no indication of any organ resembling a blepharoplast or centrosome could be discovered at the pole of the spindle. The difficulty of obtaining this cell in stages of division, however, has prevented a very thorough examination at this stage. After the division is completed in stages like that represented in figure 18 and slightly later, a very careful examination fails to reveal a trace of any organ which could be considered to be an early stage of the blepharoplast. When the central cell has increased in size to about twice the diameter it had immediately after its reorganization, the blepharoplasts first begin to appear. (Compare figs. 19 and 24.) In *Zamia floridana* in 1898 the blepharoplasts appeared mainly between March 5 and March 15, while in *Z. pumila* the same year they appeared mainly between March 10 and 25. It is probable that the date of their appearance may vary somewhat in different years, and the time of their appearance in different plants and even in different ovules of the same cone is very variable. Indeed, great difference has been noted in the time of their appearance in different pollen tubes in the same nucellus. It is interesting to note that the pollen tubes have considerable individuality apparently, and vary greatly in their stage of development, size of organs, etc. In tubes on the same nucellus the writer has found in some the fully developed spermatozoids, while in others the central cell had not yet divided.

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[1] A term applied by the writer (124, 1897), to the cilia-forming organ of the spermatogenous cells of *Zamia* and *Ginkgo* which so nearly resembles a centrosome or centrosphere. The term is derived from βλεφαρις, eyelash or cilium, and πλαστος, formed.

In the earliest stage in which the writer has been able to surely recognize the blepharoplast, it seems to be made up of a small, deeply-staining granule from which several filaments of kinoplasm radiate, following the meshes of the reticulum. The central granule does not seem to be different in substance from the radiations—stains the same and shows no differentiation of structure. In this stage it is only a half micron in diameter or less and seems to be scarcely more than the point of crossing of the filaments of kinoplasm. They are located in the cytoplasm about halfway between the nucleus and the cell wall. Two are formed in each central cell at the same time and apparently independently. They are commonly located on opposite sides of the nucleus, but in a number of cases in this stage and in a still later stage they have been found nearer together, frequently less than 45° apart (figs. 19 and 25). The cytoplasm at the time the blepharoplasts appear forms a loose, open, reticular structure, and the rays which extend out from the blepharoplasts seem to run into the walls of the reticulum. The rays in this early stage are comparatively few and short. The nuclear plasm shows a reticular structure much finer than that of the cytoplasm and surrounds a large nucleolus. In the several instances of this early stage of the blepharoplast which have been observed they are located about midway between the nuclear membrane and the cell wall. In what seems to be a slightly later stage, however, when the blepharoplasts have grown considerably in size and show a distinct spherical body at the point of the converging rays, they are found quite close to the nuclear membrane, which is commonly slightly indented just below them (fig. 19).

In *Cycas*, according to Ikeno (70, p. 571), the two blepharoplasts appear in the central cell shortly after the division which gives rise to this cell and the stalk cell. They arise as two small bodies which at first lie close to the wall of the nucleus. No radiations are visible from them for a considerable time. In this latter feature they seem to be considerably different from *Zamia*, where the radiations are visible and conspicuous in the youngest stage which can be detected. In *Ginkgo*, also, as shown by the writer (124) and Hirase (62), the blepharoplasts appear in the central cell just after its formation, arising in the cytoplasm near the nuclear membrane. It is probable that *Zamia*, *Cycas*, and *Ginkgo*, agree in their main features, the absence of radiations in *Cycas* being probably due to the method of preparation.

In this stage of development in *Zamia* the central cell is still almost spherical, being flattened at the point of attachment with the stalk cell, as is shown in figure 19. Here the central cell is only about 36 μ in diameter, while the nucleus is about 18½ μ, the nucleolus 4½ μ, and the blepharoplasts 1 μ in diameter. The first prothallial cell is shown here very plainly, pushing up into the stalk cell, extending fully two-thirds of the distance through it. The nucleus of the prothallial cell and that of the stalk cell are about the same size, the latter nucleus having increased in size since the stage illustrated in figure 18, and become somewhat compressed and lenticular from pressure. The pollen tube at this stage has reached a length of about 1 mm., and is at most places in the tissue from 40 to 50 μ in diameter, though this varies considerably. The protoplasm forms an open foam structure with large vacuoles, about the same as illustrated in figure 19. Starch grains have already become abundant in the tube, but are not so large or so numerous as in later stages. In the section figured no starch grains were visible in the stalk cell or prothallial cell, although in some instances they are formed in a still earlier stage.

The first indication of differentiation in the blepharoplast, as it increases in size, is the formation of an outer membrane or wall (fig. 25). By this time the blepharoplasts have moved somewhat farther away from the nucleus and the kinoplasmic radiations have become much longer, more prominent, and apparently more numerous. The central cell has also increased in size, as well as the entire prothallus. Up to this time the central cell has been nearly spherical in outline, and the blepharoplasts, so near as the writer has been able to observe, did not seem to occupy any definite position in reference to the attachment of the stalk cell. As the apparatus increases in size the central cell elongates and becomes elliptical or oblong, its major axis corresponding to the longitudinal axis of the pollen tube (fig. 20). The blepharoplasts during this development take up a position on opposite sides of the nucleus almost exactly on the major axis of the cell. In almost all of the cells in this stage of development the blepharoplasts occupy this position. In a number of instances, however, they have been observed to remain much closer together, and in some instances never assume a position opposite each other. In this early stage of development the central cell presents a beautiful reticular structure (fig. 26), the meshes of the reticulum being rather large. The kinoplasmic filaments are but little more prominent than the walls of the reticulum into which they seem to run and disappear. The individual filaments themselves seem to be composed of fine granules and are, the writer thinks, quite surely threads and not plates. By carefully focusing above or below the blepharoplasts, irregularly arranged granules are seen which seem to indicate the thread-like nature ot the radiations. These granules are interpreted as being cross sections of the kinoplasmic filaments. This, the writer is aware, is a disputed point in the structure of the kinoplasmic rays, and he has therefore very carefully examined many slides in the hope of being able to settle this question, at least in *Zamia*. The radiations are larger and coarser in *Zamia* than in any other plant which has come under the writer's observation, and it would seem to be a very favorable subject for the study of such disputed points. The cytoplasm, viewed in cross or longitudinal section, presents the same irregular meshes, and while the writer is inclined to view this as a foam structure, it is a point on which he has arrived at no very satisfactory conclusion.

As the pollen tube apparatus continues to grow the blepharoplasts also increase in size, and about the first of April the contents, which stain red with safranin in the Flemming triple process, become more or less vacuolate (fig. 29). This occurs when the blepharoplasts have reached about half the diameter which they finally attain. During the general increase in size the kinoplasmic rays have become more abundant and in many instances may be seen running from the blepharoplasts out to the plasma membrane of the cell with which they seem to connect.

GROWTH OF BASAL END OF POLLEN TUBE.

The entire prothallial apparatus continues to increase in size until about the middle of May in *Z. floridana* and the first of June in *Z. pumila*, when the central cell and blepharoplasts have reached their full size and the preparation for their division begins. The pollen tube, which has been gradually increasing in length and diameter, has now reached the extent of its growth in the tissue of the nucellus and has become more or less gorged with starch and reserve food materials. The tubes, of which there are commonly from 4 to 8 and sometimes as high as 13 or 14 in a single nucellus, usually grow to a length of 2½ to 4 mm. and are from 80 to 150 μ in diameter in the tissue of the nucellus. They are ordinarily unbranched, but occasionally a branched tube is observed. The writer has never observed an instance where a tube had branched more than once. At this period of development, and later until fecundation takes place, the pollen tubes can be plainly seen in an examination of the apex of the nucellus with the unaided eye. The tissue next to the tubes is brownish or yellowish, clearly marking the path of the tube. Furthermore, the tube usually causes a protrusion of the nucellar tissue over it, which makes its course easier to follow. It is particularly interesting to note that when several tubes develop in the same nucellus they apparently do not grow altogether at random, but divide the space almost equally, radiating out from the pollen chamber as a center, with almost equal angles between them. There is no special structure of the nucellar tissue which guides this distribution of the tubes, so far as can be observed, and the pollen grains are apparently not guided in their distribution or position in the pollen chamber. When a number of grains are found in the same nucellus they may be scattered in the lower part of the pollen chamber or grouped more or less together. When they germinate, and the tubes turn toward and enter the nucellar tissue, two or more may be found to enter the tissue and start in the same direction. As they elongate, however, they diverge and divide the space between them, and this is a very necessary provision, apparently, as they are so large that in the thin nucellus of old stages there would not be room for them to grow together and cross. The writer has examined several thousand ovules in condition to show this feature well, and in no instance have two tubes been found very close together. In case there are many tubes they are necessarily nearer together than when there are only a few tubes. If there are only two or three tubes they may not divide the space exactly equally between themselves, but are invariably found to be separated by a fairly wide angle. In no case have the tubes been found bunched together on one side of the nucellus, as would occasionally occur if there were not some force guiding their direction of growth. It seems probable that when a tube enters the nucellar tissue it may produce a chemical change of some sort which serves to repel other tubes. It may, on the other hand, be simply a reaction to richness of food supply. Their distribution and growth in the nucellar tissue seem similar to that of root distribution in the soil, exclusive of the factor of light.

During the growth of the pollen tubes the nucellus has continued to change considerably in form and shape. In the early stages of growth the apex of the nucellus has a considerable thickness compared with the pollen tubes (fig. 5). The tubes at first grow straight out laterally in the apical tissue of the nucellus (fig. 5), but before reaching the surface they turn downward and continue growing down through the tissue of the sides of the nucellus just underneath the surface (fig. 51). As the development continues the nucellus grows in size, but gradually becomes thinner, until at the time of fecundation it is reduced to a thin, papery membrane, except at the apex, where other changes have meanwhile taken place. The tissue below the apex of the nucellus which was at first pointed becomes more or less contracted and sunken, as shown in figure 51. The tissue below the pollen chamber and between it and the prothallus, which is at first about 2 mm. in thickness, is gradually absorbed and finally entirely breaks away, leaving an opening from the pollen chamber into the archegonial chamber. The pollen tubes in early stages grow straight out laterally, the pollen grains being frequently above (toward the apex of the tube), so that the tube in germination at first pointed downward and then curved to one side in entering the tissue (see two lower tubes in fig. 5). Such tubes as these, and also those which develop in other directions, become reflexed during the changes which occur in the apex of the nucellus, and finally the proximal ends of all tubes (the pollen-grain end) are found to be turned down so that they point toward the prothallus. A short time before fecundation, active growth begins in this end of the tube. The proximal ends of the tubes elongate and push down in the pollen chamber farther and farther, the cavity becoming larger and changed in shape. Finally the tissue of the nucellus below the pollen chamber breaks away and the pollen tubes hang down in a cluster in the archegonial chamber. They continue to grow in length until, at the time they burst and discharge the spermatozoids in the process of fecundation, the proximal ends, which hang down free from the tissue (fig. 51), have reached a length of from 1 to 2 mm. During this growth and up to the time the tube bursts the old pollen grain forms a little protruding end at the tip of the tube, which remains covered by the exine of the pollen grain. It stains red with safranin in the Flemming triple process, and is thus easily differentiated.

An extremely interesting fact in connection with the pollen-tube development is the migration of the pollen-tube nucleus, which takes place apparently at the beginning of the active growth and extension of the proximal end of the tube. It will be remembered that when a pollen grain germinates the tube nucleus passes out of the pollen grain and takes a position near the end of the growing pollen tube, and during the entire active period of growth of this end of the tube remains relatively in this position, passing farther into the tube as the latter extends in length. In the course of the investigations it was found that when the active development had begun in the basal end of the tube, a nucleus corresponding in size and appearance to the tube nucleus was almost invariably found somewhere near the central cell. At first it was thought that this was an abnormal occurrence, the pollen-tube nucleus having remained attached to the prothallus in some way and failing to migrate into the pollen tube, as it developed, in the normal way. Investigations showed that this nucleus, however, is normally found near the central cell in this stage of development. It would seem, therefore, that either it must be the pollen-tube nucleus which has migrated from the apical end of the tube to this location or that the pollen tube nucleus divides at some time during the development of the tube, and that one of the two nuclei remains in this location. Juranyi (72) found that in the pollen tubes of *Macrozamia*, grown in artificial cultures on pieces of soft pear fruit, the pollen tube nucleus after a time often divided into two; however, he apparently did not observe the process of division leading to the formation of the second nucleus, and Strasburger was unable to confirm this portion of Juranyi's observation.[1] Recently, however, several investigators have found the pollen-tube nucleus in various other plants to divide, at least occasionally. This was first observed by Chamberlain in *Lilium philadelphicum* (19), and later by Fullmer (42) in *Hemerocallis fulva.* A somewhat careful search was therefore made in various stages of developing pollen tubes of *Zamia* for a division of the pollen-tube nucleus, but no indication of such a division has ever been observed. Furthermore, in an examination of the tubes where the nucleus is found near the central cell no case has been found where a second nucleus occurs at the apex of the tube. It would thus seem that the tube nucleus remains at the apex of the tube as long as this is the end where the most active growth is taking place, and then, when the active growth begins at the base of the tube in its elongation preceding fecundation, it migrates to that end of the tube in order to be near the point of greatest activity and superintend the growth of the pollen-tube wall in this location. Haberland (50), in his extensive paper on the relationship between the function and position of the cell nucleus in plants, has shown that the nucleus ordinarily takes position in the cell near the point of most active growth. The writer has come to the conclusion that in *Zamia* the pollen-tube nucleus remains normally near the distal end of the tube as long as the tube is growing in length and absorbing nutrition. The growth of the basal end of the tube does not start, apparently, until the tube has attained its full development in length in the apical portion. The tube nucleus then migrates to the base of the tube, the increased length of that end of the tube being due to the growth of the pollen tube in that region, thus necessitating the presence of the nucleus. This migration of the pollen-tube nucleus was not discovered until the writer was closing his investigations, and has not been as thoroughly investigated as the other processes of development described. He feels, however, that there is but little doubt of the correctness of the interpretation. Since this conclusion was reached the writer finds that the same migration of the tube nucleus was observed by Ikeno (69, p. 573).

> In the middle of September the embryonal nucleus [tube nucleus] begins to move forward toward the body cell (fig. 22a, Pl. IX), and by the end of the same month it comes in contact with its posterior end, so that at this time the body cell and the outer prothallial cell, as well as the embryo-cell and stalk-cell nuclei, meet at the terminating exine end of the pollen tube.[2]

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[1] Ebensowenig trat über geprüften Falle der Pollenschlauchkern auch nur ein einziges Mal in Theilung ein. (Strasburger, 109, p. 3.)

[2] Mitte September beginnt der Embryonalzellkern [tube nucleus] nach der Körperzelle sich hinzubewegen (fig. 22a, Taf. IX) und Ende desselben Monats kommt er in Contact mit ihrem hinteren Ende, so dass zu dieser Zeit sowohl die Körperzelle und die äussere Prothalliumzelle, als auch der Embryonalzell- und der Stielzellkern an dem mit der Exine abschliessenden Ende des Pollenschlauches zusammentreffen.

Hirase (61) has also found that there is a similar return of the tube nucleus to the pollen-grain end of the tube in *Ginkgo*, so that the process would seem to be a general one in cases where this type of fecundation occurs.

During the downward extension of the basal end of the pollen tube the prothallial apparatus remains attached to the base of the tube and is carried down with the tube in its elongation. The central cell in the course of this development is frequently compressed and drawn out so that its shape is greatly altered (figs. 48, 49, and 51). In stages preceding this development the central cell is normally elliptical or oblong, its major axis corresponding to the major axis of the pollen tube (fig. 20). After the tube has turned downward and is sufficiently developed so that the basal end is free from surrounding tissue, the central cell rounds up and becomes nearly spherical.

In the course of this development and change of the basal end of the pollen tube and the prothallus, the blepharoplasts have also changed their position. Previous to this development they occupied the poles of the nucleus, a line passing through them corresponding to the major axis of the cell and longitudinal axis of the pollen tube. During the growth of the basal end of the pollen tube and consequent change of the prothallus they have changed their position in regard to the pollen tube and nucleus and have come to lie at opposite points on the equator of the nucleus transverse in the pollen tube (as shown in figure 21, though this is after the division of the cell). The writer has not been able to determine whether this change in position of the blepharoplast is due to a definite motion of the blepharoplasts themselves or to a change of shape of the cell and nucleus. It would seem, however, that the blepharoplasts must move in the cell independent of the motion of any other organ. As the central cell is pulled down by the growth of the pollen tube it is not infrequent to find the two blepharoplasts preceding the nucleus. However, in the course of this transformation the blepharoplasts may be found in almost any position in the central cell, but usually remain nearly on opposite sides of the nucleus.

The entire prothallial apparatus continues to increase in size until the latter part of May in *Z. floridana* and about June 10 in *Z. pumila*, when the central cell and blepharoplasts have reached their full size and the division of the central cell begins. In this stage of development all cells of the prothallus retain their relative positions with reference to each other, but the base of the pollen tube in which the prothallus is located has in most instances begun to grow and change its position as described above, and a change in the shape of the central cell has frequently resulted before this stage is reached. The first prothallial cell and stalk cell in this stage retain the same position as described in the preceding stage, but have greatly increased in size (fig. 21).

Both the first prothallial cell and the stalk cell have become filled with numerous starch grains, which are frequently compound (fig. 21), and a cross section of the tube through these cells at this stage (fig. 23) presents a puzzling structure until the method of development of the interior first prothallial cell is understood. Even in this greatly enlarged mature stage the original end of the attachment of the first prothallial cell with the old pollen grain remains the same size as in the early stages (compare figs. 20 and 21), and the point of attachment of the plasma membrane of the second prothallial cell (now a part of the plasma membrane of the stalk cell) is the same distance from the point of attachment to the pollen tube as in the early stages (fig. 21).

The central cell, which just after its formation by the division of the second prothallial cell was about 16.91 μ long by 15.57 μ wide, and which at the time the blepharoplasts appeared had reached a diameter of about 36 μ, now commonly measures 170 μ in width by 190 μ in length. Its size, however, is very variable. The blepharoplasts in which greatest interest centers have also increased greatly in size, in this stage measuring from 18 to 20 μ in diameter. In many instances, probably in the majority of cases at this stage, they have become somewhat compressed at the poles, so that they are more or less elliptical in equatorial section (fig. 59) and round in polar view (fig. 60). They still retain their positions at the poles of the nucleus, lying free in the cytoplasm, in this stage usually rather nearer the surface of the cell than the nucleus, not infrequently being almost in contact with the plasma membrane, which is frequently somewhat indented immediately above them. In the course of the development the contents of the blepharoplasts, which was at first homogeneous and then slightly vacuolate, has become filled with vacuoles which present a beautiful, regular form. A few highly refractive bodies, presenting the appearance of crystals or crystalloids of some sort, are also frequently observed in the blepharoplasts at this stage (fig. 29), but the writer has been unable to learn anything as to their nature or function. In this stage the kinoplasmic radiations have become very numerous and extensive, and are more slender than in earlier stages. They radiate in all directions from the blepharoplast, but are naturally more strongly developed and longer on the sides than above toward the surface of the cell or below toward the surface of the nucleus The writer has tried to determine how the increase in number of radiations is brought about, but has been unable to solve the problem. He has found no evidence, however, favoring their increase by division, as claimed by some investigators. The cytoplasm of the central cell in this stage has become much more dense than in the preceding stage described, but still presents a beautiful reticular structure in well-stained sections. The distinction between kinoplasm and trophoplasm here is not well marked; indeed, in no place in the development of the central cell is this distinction evident. In the Flemming triple stain the fibers radiating from the blepharoplast are stained deep purple with the gentian violet as normally occurs, but the reticulum of the trophoplasm also stains the same color, though slightly lighter, and in no case has the stain showed any characteristic differentiation between them. The nucleus of the central cell in this resting stage just preceding division is in most cases strongly indented on each side just below the blepharoplast (fig. 59). It might be assumed at first that this was due to the growth toward the nucleus of the kinoplasmic filaments in an early stage of spindle formation, but careful examination plainly shows that this is not the case. The kinoplasmic rays do not crowd down against the nucleus to any extent, and the spindle is entirely intranuclear when first formed, having no connection with the blepharoplast.

DIVISION OF THE CENTRAL CELL.

The earliest stage in the division of the central cell which the writer has been able to detect occurs in the nucleus, in which here and there an accumulation of highly staining granules takes place, forming small, irregularly arranged groups (fig. 27). The blepharoplasts and other organs of the cell in this stage remain comparatively the same as in the preceding stage. The condensation of chromatin matter evidently continues, and gradually the complete continuous chromatin skein is organized. In the skein stage there seems to be nothing particularly different from the process ordinarily observed in the skein stage of other cells and plants. The chromatin band forms a loose, open coil (fig. 28), occupying but a small part of the nucleus. The small amount of chromatin visible here and in later stages seems out of proportion to the enormous size of the nucleus. Occasionally light lines can be observed radiating from portions of the skein in this stage, possibly foreshadowing the formation of the spindle. This would not seem to be the case, however, as similar lines are also observable in some instances radiating from the groups of chromatin granules in the earliest stage of division. In the skein stage the blepharoplast remains in apparently the same condition as in the preceding stage unless somewhat larger. The kinoplasmic radiations still appear very abundant. This collection of the stainable matters into groups of granules and then into a continuous skein evidently foreshadows a general contraction of the chromatin matters into an irregular mass surrounding the nucleolus, a contracted condition apparently the same as the synapsis condition or stage which occurs normally in the reducing division in the formation of the pollen grains of various plants. Its occurrence in this stage of the development of the spermatozoids or germ cells of *Zamia* is thus of particular interest. This contracted condition of the nucleus in *Zamia* has been observed in a number of instances in some of the very best fixed and stained sections, and the writer can hardly believe it to be due to contraction caused by reagents, as might be supposed. Indeed, the phenomena shown in *Zamia* would appear to demonstrate clearly that it is of normal occurrence here; for, as shown later, after this collection of the stainable granules in one portion of the nucleus, the other portion of the nucleus remains occupied by a plain reticulum of unstainable matter filled with minute refractive granules. Sargent (96) was able to observe this stage in living nuclei of the pollen grains of *Lilium martagon*, showing that in that instance the apparent contraction phenomenon was evidently a normal one. No conclusive evidence has been obtained, however, which shows its significance in the process of division. In the central cell of *Zamia* it is only occasionally that nuclei can be found in this condition, and it is not a favorable place to study the phenomenon. The collection of deeply staining granules in irregular masses would seem to be immediately followed by their gradually moving toward one side of the nucleus and collecting around the nucleolus. The nucleolus is always in the midst of the mass of granules after the completion of the contraction, and it may be that the contraction is always toward that side of the nucleus to which the nucleolus lies nearest. The conviction can hardly be avoided that the nucleolus must be connected in some important way with the collection of these granules around it. In *Zamia* the early stages at least of this phenomenon would seem not to be a contraction, but rather a movement of the stainable elements, granules, etc., of the nucleus to a region in close proximity to the nucleolus, while a colorless, slightly granular, nonstainable matter remains in the original position. This unstained plasma is clearly visible and unmistakable and retains the original reticular structure (fig. 30). It might at first be assumed that this colorless network was due to the albumen used in attaching the sections, or to some deposit from the paraffin or killing reagents. Such could not be the case, however, as in some places where the nuclear membrane had become contracted away from the cytoplasm no such structure intervened, which would have been the case had it been caused by the albumen cement or any of the other reagents used in the process of killing, imbedding, etc. By a careful examination of the edges of the dense mass of granules occasionally a place may be observed where a few of the stainable granules may be found extending out into a strand of this unstainable matter (fig. 30). It would seem from this that the chromatin granules follow along the reticulum of this hyaline plasm in the process of collecting in the synapsis stage, and that in such cases as the above a few isolated chromatin granules had not yet united with the general mass when the material from which the section was taken was killed and fixed. The reticulum of this colorless plasm seems thus to be coextensive with the reticulum of the densely staining portions of the nucleus, and apparently occupies its place throughout the nucleus, while the chromatin and linin elements are concerned in the formation of the spiral band. This hyaline plasm may probably be considered the nuclear sap or hyaloplasm which forms the ground substance of the nucleus. But it is certainly arranged in a reticulum, while the hyaloplasm or nuclear sap might be expected to fill the entire space. The chromatin and linin elements alone seem to be directly concerned in the formation of the spirem stage which follows, though this can only be conjectured. The granules which are observable in the stainable portion of the nucleus while in this condition are of two kinds. The larger ones, which are round or elliptical in form and quite regular in outline, stain red with safranin in the Flemming triple-stain process, and have the same structural appearance as nucleolar matter, and, as they disappear later in the development of the chromatin spirem, it is probable that they are some form of reserve food matter which is used up in the further process of development. The other granules stain a deep purple-like chromatin, and are probably of this nature, as they appear to form a part of the chromatin spirem, which can be observed in process of formation in the synapsis condition. By a careful study of the coarsely granular stainable mass of the nucleus in this stage it can be discerned, particularly in the outer portion of the mass, that the smaller protein granules are arranged in chains, which are contorted and tangled together so closely that the arrangement can not easily be made out.

The synapsis condition of the nucleus has been observed by numerous investigators, among them Strasburger (108, figs. 3, 66), Farmer (33, p. 473), Calkins (18, p. 105, fig. 3), Sargent (96), Duggar (29, p. 82), Davis (26, p. 96), etc. Its occurrence is now so widely known that there would seem to be no doubt that it is a perfectly normal stage in certain nuclear divisions. In this stage (fig. 30) the blepharoplast, which has become elliptical in most cases, remains apparently unchanged. The radiations of kinoplasm are very abundant, as in preceding stages. The cytoplasm presents a fine reticular structure, the kinoplasmic threads corresponding with the network of the cytoplasm, being nearly straight in the vicinity of the blepharoplast and more or less waved after receding some distance from it. Scattered here and there in the cytoplasm are numerous perfectly round globules, staining exactly the same as the rest of the network of cytoplasm, but seeming to lie between the meshes of the reticulum. They would seem to be excretionary granules of some sort (metaplasm), but their origin and nature have not been followed out.

The above sequence of stages in the prophases of division seem to the writer to be the most probable interpretation, but he feels that the matter is still in some doubt.

The next stage in the division which the writer has been able to observe is when the nucleus is in one of the closing prophases of division approaching metaphase and the spindle is mainly formed. It is highly important to understand the details of spindle formation, because further light might be thrown on the nature of the blepharoplast, but the writer has not been able as yet to find the necessary intermediate stages to make the process clear.

In the next stage which has been observed the spindle is in an advanced stage of formation and the chromatin matter has become contracted to the center of the nucleus (fig. 31). The nuclear membrane is still intact throughout, the spindle being entirely intranuclear. The spindle fibers which are plainly visible do not as usual draw together at the poles and form a sharp-pointed spindle, but in this stage form a blunt-poled or barrel-shaped spindle, something similar to that described by Fairchild in Basidiobolus (31, figs. 3 to 6). Certain groups of fibers can be seen to be attached to certain chromosomes and extend in a well-differentiated bundle toward the pole, reaching in this stage to the nuclear membrane, which is still apparently intact throughout, being as plainly visible at the poles as in any other region. This would point to the nuclear origin of the spindle, though it is of course possible that the kinoplasmic filaments surrounding the blepharoplast could have penetrated into the nucleus and served to form the spindle. This, however, is not thought to be the case, although it may be remarked that the radiations from the blepharoplast, which were so striking in the early stages of development, are not nearly so prominent in this stage. The intranuclear origin of the spindle, while not of common occurrence, is nevertheless found in some instances among plants, as in the case of *Valonia*, described by Fairchild (30, p. 336), and *Ascophyllum*, described by Farmer and Williams. The latter authors say:

> An interesting feature presented by the achromatic spindle in this, and especially also in the following oogonial divisions, as well as in the divisions of the oospore, lies in the fact that it is largely intranuclear. It begins to be formed before the nuclear wall can be seen to be broken down at the two ends * * * (37, p. 625).

In this stage of the division of the central cell in *Zamia* the nucleolus has already entirely disappeared. The nucleus has the shape of a biconvex lens, being almost elliptical in section, its minor axis corresponding usually to the major axis of the cell (fig. 31). The spindle does not occupy the entire nucleus, and at each side the protoplasm retains the reticular form similar to its structure before the spindle began to form. The most noteworthy variation in structure occurring in the cell at this stage of the division is in the blepharoplast, which has undergone a striking change since the last stage. It has increased in size somewhat, and the outer membrane has separated from the contents, which in the meantime has shrunken somewhat, though not very markedly as yet. The outer membrane of the blepharoplast stains more deeply purple with Flemming triple stain, and has separated into fragments or plates, a cross section in this stage showing a broken line. The separations in this stage, however, are yet quite irregular and infrequent. The content of the blepharoplast has contracted considerably, but still retains its vacuolate appearance (fig. 32). The kinoplasmic radiations which in the preceding stage were very strongly developed evidently almost disappeared at this stage, as several well-stained sections of nuclei in this stage show at best only slight suggestions of radiations. The reticulum of the protoplasm is so arranged as to give the suggestion of radiations immediately adjoining the blepharoplast. What becomes of the radiations the writer is unable to say. They may in some way aid in the spindle formation, but the nuclear membrane still remains unbroken. Wilson says that "it is now generally agreed with Van Benedin that the mantle fibers are essentially a part of the asters—i. e., are simply those astral rays that come into connection with the chromosomes" (130, p. 79). This is certainly not the case in *Zamia*, unless we can imagine the rays of the blepharoplast swinging around, losing their connection with the blepharoplast, and penetrating into the nucleus through a well-formed nuclear membrane. The mantle and interzonal fibers of the spindle are both formed and the spindle apparently fully developed before the nuclear membrane breaks down.

As the division progresses and reaches about the metaphase the outer membrane of the blepharoplast becomes more plainly segmented (fig. 61, photograph) and the vacuolated content has become more shrunken and is plainly disappearing. During the metaphase, or slightly before or after, the nuclear membrane breaks up and would appear to become transformed into spindle fibers, which remain in the position previously occupied by the nuclear membrane and preserve the outline of the nucleus.

In an early anaphase of division (figs. 33 and 62) the dividing nucleus presents a perfectly normal appearance so far as the main features of division are concerned. The chromosomes have just pulled apart and are approaching their respective poles; the nuclear membrane has disappeared, but the outline of the nucleus is still preserved by fibers which seem to have been formed by the disorganization of the nuclear membrane. The disappearance of the nuclear membrane seems to be gradually accomplished by its breaking down and becoming directly transformed into fibers of the spindle, outside of the mantle fibers, which spread out in each direction toward the periphery of the cell and later take part in the formation of the new delimiting plasma membrane. A layer of cytoplasm around the nucleus and a hemispherical mass of cytoplasm at each pole presents a different structure and staining capacity from the general mass of the cytoplasm. It is composed of a more open reticulum, which does not stain so deeply as the more dense outside portions. The poles of the spindle end in this open cytoplasmic mass, and it is in these light polar areas that the daughter nuclei are finally organized. The blepharoplasts lie entirely outside of these light areas a considerable distance from the pole of the spindle. This can be observed more clearly by examining figure 34, which is an enlarged section taken out of cell photographed in figure 62. It will be noticed here that the spindle fibers come to a focus in the lower part of the figure. If now a centrosome or centrosphere of an ordinary kind was present it should be located where the spindle fibers come to a focus. This location, however, is occupied by no body which could be considered to be a centrosome. A most careful examination of the protoplasmic structure has been made at this stage of division and no connection can be discovered between the spindle and the blepharoplast. The radiations from the blepharoplast are, as in the preceding stage, rather inconspicuous and seem to be merely due to the arrangement of the reticulum. Between the ends of such radiations as can be observed and the pole of the spindle lies the hemispherical mass of polar cytoplasm, in which the reticulum presents a totally different appearance from that of the other cytoplasmic areas. The protoplasm here is made up of a loose, open reticulum, in which individual threads may be frequently observed to run for a considerable distance in the same plane. The spindle fibers run into this mass and end rather abruptly, not extending up into it. The spindle fibers can not be confounded with the fibers of the reticulum. There can be no doubt that no fibers run from the spindle to the blepharoplast in any sense in which the spindle fibers focus on a centrosome or centrosphere when such an organ is present. The spindle formation and structure were not investigated in much detail by Ikeno and Hirase; but this same peculiarity of structure would seem to be present also in the plants they studied. Hirase's figure 18 (62) clearly shows that the radiations from the blepharoplast do not connect with those from the spindle, and the pole of the spindle is illustrated as having an entirely separate aster, in the center of which a centrosome should be located if any such organ is present. This is not so clearly shown by Ikeno's figure 3, but in his figure 25a (70), where the nucleus is in an anaphase of division, the blepharoplast is very distant from the pole of the spindle.

The structure of the blepharoplast of *Zamia* in this anaphase is also particularly interesting. The outer membrane is still observed to be split up into a number of segments. The membrane itself in cross section when very carefully examined seems to be made up of numerous granules of comparatively the same diameter placed side by side and making up the membrane. This structure is particularly interesting in connection with what follows when the membrane is broken up and appears merely as a group of numerous granules.

The contents of the blepharoplast, so far as the stainable matter is concerned, has entirely disappeared, and inside of the blepharoplast now a clear hyaline plasm is visible, forming a delicate reticulum with large meshes somewhat similar to the plasm found in the colorless parts of the nucleus in the synapsis stage of division. What has become of the dense stainable matter which previously occupied the center of the blepharoplast? It will be remembered that this matter appeared largely like nucleolar matter, remaining homogeneous but vacuolate, and staining deep red with safranin. Its contraction away from the outer membrane of the blepharoplast during division and its gradual disappearance as above described indicates that it may have been utilized as reserve food material to provide for the active growth which has been taking place in the blepharoplast itself and in other parts of the cell. The growth of the outer membrane of the blepharoplast in thickness and the appearance of granules in the structure of the membrane is evidently correlated in some way with the disappearance of its contents. When the daughter nuclei organize in an early telophase, they are at first strikingly small in comparison with the organizing daughter cells and the nucleus of the mother cell. Figure 35 shows a drawing of a fairly early telophase, and a photomicrograph of the same cell is shown in figure 63. The nuclei of the daughter cells in this case have reached the daughter spirem stage, the chromatin spiral being plainly visible in one of the nuclei. The nuclei are elliptical in shape, being from 20 to 22 μ long and from 12 to 13 μ wide. The daughter nuclei are located in a portion of the cytoplasm, having a different reticular structure, which evidently corresponds to the specialized polar areas of cytoplasm described in the preceding stage. The spindle fibers have bulged out on each side of the old mother-cell nucleus, reaching the cell wall on each side. They have contracted away from the daughter nuclei, and seem at their outer ends to be in the process of gradual transformation into the normal reticulum of the cytoplasm. No visible thickening occurs on the fibers where the new plasma membrane is to be formed, but a space free of granules and stainable matter clearly shows where the new plasma membrane delimiting the two cells will form. This is particularly well shown in a photomicrograph of the cell shown in figure 63.

The blepharoplast, which in the preceding stage was separating into plates or fragments and showed itself in cross section to be made up of numerous small granules so placed together as to form a membrane, is in this stage represented by a group of numerous round or oblong granules clustered together in a somewhat irregular, more or less spherical mass, which stains the same as the outer membrane of the blepharoplast. It would seem that the outer membrane of the blepharoplast breaks up into numerous segments or granules, which assume a roundish or elliptical form and through the action of the cytoplasm become crowded together in a mass occupying the position of the original blepharoplast. In the cell shown in figure 35 the granules are from one-half to 1 μ in diameter and stain deep purple with the Flemming triple stain, as does the nuclear membrane. The mass of granules here occupies more space than the daughter nuclei and form a somewhat rectangular mass from 10 to 13 μ wide by from 20 to 22 μ long. The cell figured here is smaller than usual, being only 132 by 174 μ. The radiations from the blepharoplast would seem to be simply accentuated strands of the reticulum, the radiations running irregularly and corresponding with the walls of the cytoplasmic meshes. The radiations are by no means plain in this stage, and end rather indefinitely when they approach the granules of the blepharoplast. There is no indication of any membrane surrounding the blepharoplast in this stage.

In a late telophase, when the daughter nuclei approach a resting condition they are found to have greatly increased in size, while the group of granules remains of comparatively the same size, and to all appearances unchanged. In this closing stage of the division, however, a most wonderful process is just starting the organization of the cilia-bearing band of the spermatozoid, which is formed by the union of the granules of the blepharoplast. At first the band can be detected only as a delicate, short, deeply stainable line, extending from the group of granules of the blepharoplast toward the nucleus. At first apparently only one of these lines can be observed, but shortly, as development progresses, a similar line can be observed protruding from the mass of granules on the opposite side (fig. 39). At first the band is very narrow, being scarcely more than a line. It gradually increases in width, however, as it increases in length, till it soon has an appreciable width. While there would seem to be no possible doubt that the band is organized at the expense of and by the granules of the blepharoplast, the details of the process of the organization is somewhat difficult to discover. In some sections the writer has been able to distinguish what seems to be individual granules of the blepharoplast fusing with the band where it joins the mass, several of the granules that have united with the band still showing their individuality (figs. 36 and 37). Again, in bands which have developed considerably the thickness seems to be continually added to by the fusion of other granules with it directly on the edge which lies next to the mass of granules (figs. 38 and 64). It is not infrequent to find sections showing indications of this sort, which suggest the union of the granules together to form the band. Furthermore, as the band grows in length the granules of the blepharoplast gradually disappear till all have been absorbed in the growing band. The writer thus feels that there is little doubt of the correctness of the interpretation. This history of the origin of the cilia-bearing band by the fusion of the granules of the blepharoplast was first described by the writer at the August 22, 1898, meeting of the American Association for the Advancement of Science, and was published in Science, November 11, 1898 (127). The same conclusion as to the origin of the cilia-bearing band in *Cycas* was reached by Ikeno apparently about the same time, and published in his monograph which appeared somewhat later, November 23, 1898 (70, p. 575). The beak which extends out from the nucleus to the blepharoplast and forming band in *Cycas*, as described by Ikeno in *Cycas* (70) and by Hirase in *Ginkgo* (62), the writer has not been able to find in *Zamia*, even after renewed search. There would seem to be no reason, however, to doubt the correctness of the observations of Ikeno and Hirase. It may be that such a nuclear beak is formed also in *Zamia*, but was contracted in the writer's specimens by the reagents. There is nothing to indicate this, however, and the writer believes that no such nuclear extension or beak is formed in *Zamia*. How it could have escaped observation in the long-continued researches of the writer when special attention was given to searching for it is difficult to imagine. Similar beak-like extensions of the nucleus toward blepharoplasts have been observed by Strasburger (112) in swarm spore formation, and toward the centrosphere by Harper in the formation of the ascospore walls in *Erysiphe* (51, figs. 18–25) and *Lachnea* (52, figs. 43–45). In a late stage of the spermatozoid formation in *Zamia*, when the ciliferous band has completed its growth, numerous little points have been observed extending out toward it from the nucleus, but these extrusions are certainly not connected in any intimate way with the process of band formation.

In the stage when the ciliferous band first begins to organize, the daughter nuclei are usually approaching a resting stage (fig. 36) and one nucleolus and sometimes two have already been organized in each. The spindle fibers have shortened up materially and the cell plate is usually fairly well organized. The formation of the plasma membranes separating the two cells is frequently shown with great clearness in *Zamia* and one can observe all stages of the transformation of the spindle fibers into the reticulum on one side and the plasma membrane on the other. The spindle fibers gradually shorten in length and contract into the cell plate, apparently forming the material for the organization of the separating membranes. Even in an early stage of the organization of the separating membrane, when only a few meshes of the cytoplasmic recticulum intervene between the daughter nuclei and the ends of the spindle fibers, the place where the future cell wall will form is plainly shown by a slightly lighter, clearer area crossing the cell (figs. 35 and 63). As the cell advances thickenings appear on the spindle fibers where the new wall is to form. The fibers continue to contract more and more until they become very short. A lighter staining mass of protoplasm then shows on each side of the forming wall into which the short ends of the spindle fibers extend, and in which their gradual transformation into the ordinary reticular structure of the protoplasm seems to be taking place (fig. 44). Ordinarily the double plasma membrane can not be distinguished readily, but in some instances it is plainly discernible, being due evidently to slight contraction. In the case of the division of the central cell which gives rise to the spermatids no cellulose well is formed between the cells. In cases where such a wall is formed or normally occurs it would doubtless be laid down between the two plasma membranes. As to the question of the division of the swellings on the spindle fiber into two portions in the formation of a double plasma membrane no evidence has been obtained. The two membranes normally appear as a single membrane and apparently, unless there is some contraction, the presence of a double membrane can not be determined. The details of the origin of the plasma membrane here correspond in general, so far as traced out, with the conclusions of Strasburger. A double plasma membrane, such as is seen in the central cell of *Zamia*, is also described by Blackman (16, p. 400) in the formation of the ventral canal cell in *Pinus*.

In a stage slightly later than the one above described the division may be considered as completed; the daughter nuclei having apparently returned to the resting condition (fig. 36). The organization of the cilia-bearing band, however, is yet incomplete. The band and blepharoplast granules still lie free in the cytoplasm, about midway between the nucleus and the plasma membrane. The band by this time has grown to an appreciable thickness and increased greatly in length. It now forms a crescent-shaped body with the granules grouped on one side (figs. 38 and 64). The band in this stage is usually about 7 to 10 μ in width at broadest point.

METAMORPHOSIS OF THE SPERMATIDS.

After careful consideration the writer has concluded to adopt the zoological term *spermatids* in designating those cells which become metamorphosed directly into spermatozoids. The change in the daughter cells from the closing of the division of the central cell up to the maturing of the spermatozoids is thus discussed under the heading *Metamorphosis of the Spermatids.* The nomenclature here used corresponds with that used by Shaw (102) in *Marsilia.* The use of *spermatid* and *spermatozoid* instead of *antheroblast* and *antherozoid*, as the writer at first intended, seems commendable as terms having a corresponding meaning in zoology and thus more generally understood. The central cell and intermediate cell generations can not be given terms similar to the zoological ones, as the process of development in plants is very different from that of animals, the reducing division occurring in the division of the pollen mother cell preceding the division which gives rise to the pollen grains.

The most marked change takes place first in the ciliferous band. which continues to grow in length and width, and develops kinoplasmic radiations from the outer surface. These radiations sometimes become very prominent, reaching out nearly to the plasma membrane (fig. 41). In the majority of the writer's sections, however, no prominent radiations like these can be discovered. It is not long, however, till small papillæ are formed on the outer surface of the band which evidently develop into cilia later (fig. 40). It may be that these protuberances occur while the band is young and grow into the marked radiations later. However this may be, it is certain that in a later stage the radiations disappear again or are contracted to small protuberances on the outer surface of the band. The band up to this time lies free in the cytoplasm of the cell about midway between the nucleus and surface.

The minute structure of the band in the spermatid in *Zamia* reminds one forcibly of the structure of the tail of certain animal spermatozoa. While the band is still short, in fact almost as soon as it can be clearly distinguished to have width, one edge of the band seems to be denser and heavier than the other edge. This is the edge on which the granules unite. In the mature spermatozoid, however, this distinction in the thickness and density of the different edges of the band can not be plainly distinguished.

As the differentiation progresses the band, which has meanwhile absorbed all of the granules of the blepharoplast, becomes greatly extended in length, moves out away from the nucleus and becomes more or less closely applied to the plasma membrane of the spermatid. The band by this time has increased greatly in length and in this stage forms from one to two turns around the cell. In its growth the band is always so extended that it forms a helicoid spiral. The turns, when viewed from the apex, always running in a direction contrary to the hands of a clock, the spiral formed by the growth of the blepharoplast band is thus a levotropic one. When the ciliferous band has completed one turn around the cell it has usually taken a position on the equator of the cell in such a way that it completely encircles the nucleus of the cell. In median sections through a spermatid at this stage the band is seen in sections on opposite sides of the nucleus (fig. 42). If the series of sections of a pair of spermatids is traced through till the upper section is reached the surface of the single band will be found to stretch entirely across it above the nucleus. To reach this location from the point where it was organized by the blepharoplast granules, the band has traveled almost the entire width of the cell. It can be observed in this stage to be in close proximity to the plasma membrane, but evidently not fused with it, as the writer was at one time inclined to believe. Immediately over the band the plasma membrane of the cell is invariably strongly indented. The cilia which develop from the outer surface of the band in this stage are little more than protuberances which seem to strike the plasma membrane of the cell and finally penetrate it and grow into mature cilia. The band continues to grow in length, but meanwhile decreases somewhat in width. It is broadest near the apical end and decreases in width gradually at both ends. The elongation continues until the band has developed five or six continuous turns around the cell. In this mature condition it is found to have developed in the form of a helicoid spiral with the apex located at the point of the cell corresponding to the original position of the blepharoplast. It is thus opposite the point of contact of the two spermatids in each case. During the growth of the ciliferous band the nucleus of the spermatid has increased in size, growing very markedly at the expense of the cytoplasm. The entire cell increases in size meanwhile, but not so rapidly as the nucleus.

STRUCTURE AND FORM OF THE MATURE SPERMATOZOID.

The mature spermatozoids, before they start to swim, differ but little in appearance from the spermatids in the last stage described (fig. 42). In all cases the two spermatozoids which result from the division of the same central cell remain attached together until active motion starts. When mature, and before separating, each spermatozoid is irregularly hemispherical in shape (fig. 45). The nucleus occupies a large portion of the cell, but is plainly surrounded on all sides by a layer of cytoplasm. The karyoplasm is coarsely reticular and open, and there is almost invariably one or two nucleoli present. The cytoplasm surrounding the nucleus on all sides is very densely granular and stains deep violet blue with the Flemming triple process. It is so densely granular that it is almost impossible to distinguish the reticular structure of the protoplasm. The ciliferous band in the mature spermatozoids is plainly shown, forming a helicoid spiral of from five to six turns which covers about one-half of the body of the spermatozoid. At the apex of the spiral the band apparently leaves the surface of the cell and gradually fades out, the small end occasionally making a complete but inconspicuous turn in the cytoplasm of the cell. At the open end of the spiral the band decreases in width and finally fades out entirely. The band retains the shape described in the older stages of the spermatid, being distinctly broadest near the apical end of the spiral and becoming narrowed to a point at each end. The following is the width of the band at each of the six cross sections on one side of a spermatozoid in a median section, beginning at the apex of the spiral: 5.1 μ, 8.9 μ, 7.7 μ, 5.1 μ, 5.1 μ, 3.8 μ. These figures would correspond closely with those taken from any other full-grown spermatozoid in section. The plasma membrane over the band is strongly indented both in spermatids before motion has started (fig. 45) and in the spermatozoids swimming free. This forms a deep helicoid furrow on the outside of the spermatozoid body. Below this indentation lies the ciliferous band, frequently in such close connection with the plasma membrane that it is difficult to determine that the band has not fused with it. In some instances, however, in the most mature specimens, it can be seen that the band remains distinct and that the very numerous cilia growing from it penetrate through the plasma membrane (fig. 46).

An interesting question is presented in regard to the structure of the ciliferous band. In some sections it would seem to be made up of numerous fine granules placed together side by side in such a way as to form a connected membrane, and the cilia appear to grow from these granules. It would be interesting to know if these individual granules are the same granules in each case as occurred before the organization of the band when the blepharoplast had broken up into a mass of granules. While this would seem probable and a natural sequence, no direct evidence has been discovered in its support. It might be added that the number of cilia on the band would seem to be larger than the number of granules in the blepharoplast, but no actual estimation of the number of these has been made in either case. The development of the cilia from definite granules in the band can be analogized with the granules which Strasburger found at the base of the cilia in the swarmspores of *Œdogonium Vaucheria*, etc. (112).

Another feature of importance in the spermatozoid formation of *Zamia* is the metamorphosis of the entire spermatid cell into a spermatozoid. In the writer's preliminary papers it was pointed out that when the central cell divides to form the spermatids a plasma membrane is formed entirely across the cell, and that in the transformation of the two daughter cells or spermatids into the spermatozoids these cells are transformed directly into the spermatozoids without the formation of a new plasma membrane. There is thus no formation of the spermatozoids inside of a mother cell and the differentiation of new walls around the spermatozoids, as had been described in all previous cases of spermatozoid formation, so far as known to the writer. The correctness of the writer's observations were questioned by some botanists, and this has led him, in later investigations, to give special attention to this point. Further study, however, has only confirmed the view first stated. The spermatids are made up of the entire daughter cells resulting from the division of the central cell. The correctness of the writer's observations on this point were confirmed by Ikeno in his study of the spermatogenesis of *Cycas* (70), where no mother-cell membrane or wall inclosing the spermatozoids was found. In *Ginkgo* the matter still remains in doubt. Hirase (62) does not discuss the matter directly, but his figures, 19, 24, 26, and 28, might be taken as indicating an inclosing membrane. Fujii's figures (40, figs. 2 and 5) also represent the formation of the spermatozoids inside of a mother cell, although here again apparently no special attention was given to this point, and the appearances of the figures, as will be shown later, are capable of other explanation. Coulter and Chamberlain have recently called attention to this apparent difference between the development of *Zamia* and *Cycas* and *Ginkgo* (24, p. 44). The same authors draw a distinction between the spermatozoids of *Zamia* and *Cycas* and those of lower plants which the writer thinks can hardly be maintained. They say: "It is these ciliated cells which have been called spermatozoids or antherozoids, and such they are physiologically. Morphologically, however, they are sperm mother cells which do not organize sperms, a fact which seems true of all spermatophytes." The organization of the whole cell into a spermatozoid is considered by them to be very different from what occurs in the Pteridophytes. "The contrast with Pteridophytes, in which each mother cell organizes an internal ciliated sperm and discharges it, is sharp." It is difficult to harmonize this statement with the recent researches of Shaw (102) and Belajeff (12) on *Marsilia*, where it is clearly shown that the spermatozoid is the entire mother cell metamorphosed. It is too early to generalize, but the writer is inclined to the opinion that where spermatozoids are differentiated inside of a mother cell which is discarded it will be found that it is the cellulose shell only, if such is present, which is thrown away. The plasma membrane (*Hautschicht*), from which the cellulose wall is apparently secreted, probably draws away from the worthless cellulose shell in the spermatozoid formation so that the entire cell, morphologically, is utilized. Nothing is lost in nature as a usual thing. How then could we expect the plasma membrane, which is apparently simply a modified form of active kinoplasm, to be thrown away? The fact that a double plasma membrane delimiting the daughter cells is first formed in cell division, each cell having its own membrane, and that if a cellulose wall is formed at all it appears later between these membranes, indicates that the wall is of secondary importance, which is further supported by the fact that in many cell divisions, as in all the prothallial cells of *Zamia* and *Ginkgo*, no cellulose walls are formed, the cells being delimited only by the plasma membranes. The cell wall the writer looks upon as a secretion and not an active organ of the cell, the discarding of which could not be looked upon as indicating a different morphology. In case more than one spermatozoid is formed within a cell their formation must be preceded by karyokinesis, which would doubtless divide the protoplast into as many distinct cells.

Strasburger's recent investigations of swarm-spore formation may be cited in support of the writer's view on this point. He states that in his earlier investigations on *Vaucheria* he was mistaken in describing the dissolution of the *Hautschicht* of the sporangium and the formation of a new *Hautschicht* around each spore (112, p. 188). In the case of *Œdogonium*, also according to Strasburger, the *Hautschicht* of the sporangium goes to form the *Hautschicht* of the swarm-spore. Strasburger says: "Die Hautschicht des Sporangiums liefert auch hier thätsächlich die Hautschicht der Schwärmspore."

In studying the living pollen tubes in sugar solutions, considerable search has been made for evidence bearing on this point. In no case, however, has a definite membrane connected with the stalk cell been found inclosing the spermatozoids, which could be considered as the wall of the mother cell. When the spermatozoids pull apart, however, an appearance is sometimes observed which might suggest the presence of a mother cell wall. If mature pollen tubes, in which cilia motion has not begun, are placed in sugar solution, the cilia begin to vibrate and the spermatozoids gradually pull apart and round up, as described elsewhere in this paper. When the cilia first begin their motion the surrounding protoplasm seems to hold together and spring back and forth by the beating of the cilia, as if bordered by a definite membrane. When the spermatozoids round up they occupy less space than when they are attached and quiescent. In certain tubes the protoplasm surrounding the spermatozoids holds together tenaciously when the spermatozoids begin motion, strongly suggesting the presence of a mother cell wall. When the spermatozoid strikes against it or when hit by the cilia, the protoplasmic mass does not break up, but shows elasticity, springing in and out with the impinging of the cilia, etc. This is seen to some extent whenever spermatozoids are observed starting their motion, but it is seldom very noticeable. Usually the protoplasm soon breaks up and the spermatozoids swim about unobstructed. While these observations suggest the presence of a mother cell wall, the writer believes that it must be interpreted in another way, as it is certain from a study of prepared sections that no distinct wall from that of the mother cell is formed around the spermatozoids. It would seem that the protoplasmic structure is not easily broken up and hangs together tenaciously in some cases. Again, the plasma membrane of the pollen tube, which is a single cell, surrounds the entire prothallial apparatus, and it is probably this membrane which gives the spermatozoids some difficulty in breaking through into the general protoplasmic contents of the pollen tube. The plasma membrane of the pollen-tube cell is not so easily differentiated as that of the cells of the prothallial apparatus, but is usually clearly distinguishable, and would probably form an obstruction to any object like a spermatozoid entering it. Considering the structure and phenomena presented, the writer has been led to the conclusion that the description of the structure given in his preliminary paper is correct, and that Hirase and Fujii probably erred in figuring a mother cell in *Ginkgo*, inside of which the spermatozoids are differentiated. It is important to note furthermore that in Fujii's figures (40, figs. 2 and 5), the drawings, when critically examined, do not show the differentiation of the spermatozoids inside of the mother cell, as no wall is shown separating the two spermatozoids. When the central cell divides into two cells they are separated by a definite membrane. If, then, each one of these mother cells develops a spermatozoid internally, this separating membrane should remain between the developing spermatozoids, but this is evidently not the case, judging from the figures. Fujii's figure 2 seems to illustrate exactly the same appearance as that described above as occurring in *Zamia* when the spermatozoids pull away from each other and round up so that they occupy less space, and have their original location marked by the surrounding plasma membrane of the pollen tube. The writer believes that it may be safely concluded that *Ginkgo* corresponds with *Zamia* and *Cycas* in the metamorphosis of the entire cell, and, as stated above, believes that this method of differentiation is in harmony with what is found in *Marsilia*, and probably in other ferns and lower plants.

MOVEMENT OF SPERMATOZOIDS.

For purposes of microscopic study the pollen tubes were cut off some distance above the prothallus and placed on ordinary microscopic slides, hollow-ground slides, or in glass chambers in solutions of cane sugar. In the beginning of the studies water was used, but this proved very unsatisfactory, as the spermatozoids soon died and burst, evidently from the difference in density of water and the contents of the cells. Solutions of cane sugar of several strengths were tried and a solution of about 10 per cent gave in general the best results. By the use of this solution the spermatozoids were kept living and moving for a considerable time, making it possible to study them quite carefully in a living condition. If they are transferred to the sugar solution without injury they usually continue to move from thirty to sixty minutes and one instance was recorded where motion continued for two hours and forty-four minutes. The feat of cutting off the pollen tubes which hang down from the apex of the nucellus, as shown in figure 51, is by no means as difficult as might be supposed, judging from the size of pollen tubes and sperm cells in plants ordinarily. Here the pollen tubes and spermatozoids are so large that they are plainly visible to the unaided eye and can be easily handled under an ordinary dissecting lens. In the manipulation the ovaries are cut open and the upper part of the membraneous nucellus with the pollen tubes removed. The nucellus can then be inverted over the first finger of the left hand and held in place by the thumb and second finger. Held in this way the tubes protrude prominently and can be easily cut off with a sharp scalpel or razor and transferred to the microscopic slide. In many cases the writer succeeded in cutting off the tubes nicely by placing the tip of the nucellus with the pollen tubes uninjured on the slide in sugar solution under a dissecting microscope and while holding it with forceps severing the tubes by a lateral cut. In this way one may frequently get uninjured spermatozoids swimming free in the solution, and it is then a striking sight to observe them. It is difficult to believe that the little opaque white spheres, which can be seen very easily with the unaided eye and can even be observed to move around, are really spermatozoids. It is not a difficult matter to obtain the spermatozoids moving in *Zamia*, the writer having observed hundreds of them living and moving. He has shown them to many friends, including some twenty of the Washington botanists.

In removing the nearly mature pollen tubes the spermatozoids are found to be in various stages of development, as would be expected. In many cases tubes have been observed, before cutting them off, in which the two spermatozoids had pulled apart and were swimming free in the protoplasm. In some instances their movement in the pollen tube, before it is injured, can be observed with the aid of a hand lens. This was first noticed by my colleague, Dr. Erwin F. Smith, in material which he was looking over with the writer, and was later observed by the writer in many instances.

Evidently this is what occurs normally in the development of the spermatozoids, just before fecundation, as numerous instances have been found in prepared sections of material, just at the time of fecundation, in which the spermatozoids had broken loose from the stalk cell, pulled apart, and were swimming free in the pollen tube (fig. 68). Their lively motion probably has considerable to do with the bursting of the pollen tube when they are discharged in the prothallial cavity over the archegonia in the normal course of fecundation. In many instances tubes which were cut off and placed in sugar solution were much younger and showed the prothallial apparatus entire, exactly as shown in sections. The second prothallial cell inside of the stalk cell in such instances showed very plainly, being of a darker color than the latter. The nuclei in these two cells, however, could not be discerned in the living material, probably owing to the surrounding starch, etc. The two spermatozoids in such tubes remained attached, though apparently matured. When mature pollen tubes of this nature are cut off without injury and placed in sugar solution the prothallial cell, stalk cell, and spermatozoids can at first be seen to have their normal shape. In a few minutes, however, when the sugar has had time to diffuse into the pollen tube the spermatozoids gradually begin to move. A few cilia start the movement, contracting very slowly at first; then gradually the other cilia begin to move and the rapidity of the motion increases until soon all of the cilia are vibrating so rapidly that they can hardly be seen. The spermatozoids after starting motion soon break loose from the stalk cell, which quickly collapses. Shortly after this they begin to gradually round up and pull apart, the ciliar motion continuing very active meanwhile. As they are located previous to this, closely pressed together with their major axes crossing the tube (fig. 47a), there is not room for them to separate by pulling directly apart, so they stretch in opposite directions, bending toward the longitudinal axis of the tube (fig. 47 b and c). They continue to round up more and more and finally pull entirely apart (fig. 47d). In one tube of this nature, when first cut off and placed in sugar solution, streaming motion of the protoplasm of the pollen tube was noticed in some strands immediately above the spermatozoids. This was entirely interrupted as soon as the motion of the spermatozoids began.

In the examination of fixed and stained sections of tubes in which the spermatozoids were swimming, there seems to be very little protoplasm in the tube. The living tubes, however, present every evidence of being very turgid and completely filled, and such is doubtless the case. In tubes which are cut off quite long and are uninjured in the transfer, such as the tube mentioned above in which streaming motion was observed, the entire tube is seen to be filled with granular protoplasm, with definite strands occurring here and there. The spermatozoids when they first begin moving have some difficulty in breaking through the plasma membrane of the pollen tube cell and entering the general protoplasm of the pollen tube (see page 53); when this is accomplished, however, they swim back and forth with considerable ease. It is an interesting sight to see the two giant spermatozoids moving around vigorously in the pollen tube, bumping against each other and the wall of the tube in their reckless haste. They seldom escape from the upper cut end of the pollen tube, although they as frequently swim toward this end of the tube as the other end, so far as could be observed. In many cases the pollen tubes were cut so that the spermatozoids escaped into the solution, and in numerous other cases mature turgid tubes burst in the process of cutting, discharging the uninjured spermatozoids in the sugar solution. The writer was thus able in many cases to study the spermatozoids swimming free and observe their unobstructed motion. The plasma membrane of the spermatozoids is very tender, however, and is commonly broken in attempting to remove them from the pollen tube. When swimming free without pressure they are slightly ovate, nearly round or compressed spherical (fig. 52). They vary greatly in size, but are commonly slightly longer than broad, ranging in length from 222 to 332 μ and in width from 222 to 306 μ. The spermatozoids of *Ginkgo* are described by Hirase (62, p. 123) as being egg-shaped and 82 μ long by 49 μ wide. Those of *Cycas* are said by Ikeno (70, p. 580) to be 160 μ long by 70 μ wide. The spermatozoids of *Zamia* are thus much larger than those of *Cycas* or *Ginkgo*, and so far as the writer has been able to learn are the largest that have been observed in either the animal or vegetable kingdoms. The cilia are also very prominent and numerous, measuring from 40 to 50 μ in length. When observed under the microscope in a living condition the spermatozoids are densely granular and of a yellowish brown color by transmitted light. By reflected light under a low magnification they are white and opaque. The cilia and the helicoid spiral band to which they are attached can be easily seen, while the structure of the nucleus and cytoplasm is so similar that the nucleus can not be discerned.

The motion of the spermatozoids when swimming free in sugar solution is in no way different from their motion when in the pollen tube. The general motion is a continuous rotation of the body, always in the same direction, around an axis passing through the apex of the helicoid spiral. Viewed from the head end or apex of the spiral the rotation is in the direction of the hands of a clock and contrary to the turns of the spiral band. They roll around, first here, then there, resembling in this respect the motion of *Pandorina*. After moving about rapidly for from five to fifteen minutes they usually cease all progressive motion, but continue to rotate for a considerably longer period. The rotary motion also soon ceases, but the cilia continue to vibrate for a considerably longer time. The spermatozoids of *Zamia* also have an amœboid motion, which is particularly noticeable while they are inclosed in the pollen tube. The apex of the spiral as a whole frequently rotates in a most remarkable way, turning in a circle, pushing out first this way and then that way with the greatest freedom of motion, as if selecting a point of exit or ingress. In other cases the base or the side of the spermatozoid body may be considerably extended as a blunt point in pushing between two obstacles. The whole body seems flexible and changeable in the highest degree and is eminently fitted for its difficult task of finding and swimming through the narrow passage between the neck cells of the archegonia. This amœboid motion is highly suggestive in connection with the possible motility of nonciliated sexual cells in sea weeds and seed plants. It seems almost certain that the spiral sperm cells that have recently been described as occurring in a number of seed plants—*Lilium* (Nawaschin, Guignard), *Fritillaria* (Nawaschin), *Triticum* (Goroschankin), *Silphium* (Merrill), etc.—will be found to have such a rotating amœboid motion even if they are not ciliated. The writer is not aware that attention has before been called to this mode of motion in sperm cells.

The vibration of the cilia in vigorous spermatozoids is exceedingly rapid and difficult to study. Judging from observation made on certain spermatozoids just starting motion and others which had nearly exhausted their energy, there would seem to be a rhythmic contraction of the cilia which passes quickly from one end of the band to the other. A tremulous vibration of the cilia, apparently independent of the rhythmic contraction, can be observed in the weaker motion of extreme youth and age. Whether this occurs in the period of vigorous rapid motion could not be determined, but there would seem to be no reason why it should. It would seem to be a nervous action connected with weakness. The motion of the spermatozoid as a whole is comparatively slow and sluggish.

The movement of the living spermatozoids of *Ginkgo* was observed by Hirase, but only in a few instances and was not carefully described. Those of *Cycas* have as yet not been observed in a living condition. In September, 1898, Fujii (39) made a somewhat detailed study of the living spermatozoids of *Ginkgo*, and as his paper is published in Japanese and is thus inaccessible to many, an outline of his observations will not be out of place here.[1] As in the case of the writer's study of *Zamia* spermatozoids published in 1897, Fujii used a 10 per cent solution of cane sugar in studying the *Ginkgo* spermatozoids, and succeeded in keeping them living for several hours.

> At 11.37 a. m. a spermatozoid escaped from a pollen tube and moved slowly, but with definite rate, for thirty minutes; afterwards it stopped and only moved its body at a definite place. At 1.05 o'clock p. m. only a ciliary movement was observed; at 1.30 p. m. it stopped all motion, as if dead, but soon afterwards it regained its ciliary movement, and finally at 2.05 p. m. it ceased all motion.
>
> The second spermatozoid studied appeared from the pollen tube at 4.20 p. m. and moved in and out of the field of the microscope for one hour and twenty-five minutes. Afterwards, by a careless mistake, the sugar solution dried up and it stopped all motion. Besides these two spermatozoids I observed four others, but they lived only a short time. One spermatozoid observed by Mr. Yobe lived for three hours.

Fujii described the motion of the spermatozoids in swimming as similar to that of infusoria.

It is a very interesting fact, as observed by Fujii, that the spermatozoids occasionally cease all motion, as if dead, and after remaining in this quiescent condition for a time begin motion again. I have observed this many times in *Zamia*. Frequently the sperms swim very actively for a time and then cease motion, as if desiring rest, and later begin motion again. It would hardly seem probable that the sperm could absorb nourishment from the surrounding media and gain energy in this way for further motion, but this may be the case.

Later, in 1899, in a second paper, Fujii (40) described further observations on living spermatozoids and the methods by which they get out of the pollen tubes in sugar solutions. An extract from his description follows:

> The spermatozoid in the mother cell moves its body gently and turns over in many directions by the ciliary movement, assuming various shapes, slightly changed by the simultaneous pressure of the mother cell and the two spermatozoids. At the same time, and owing to the same pressure, the nuclei also changed their form. The

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[1] Fujii's papers were kindly translated for the writer by Dr. H. Ikeda.

spermatozoids being soft and very elastic, recover their shape after the pressure is past. The spermatozoids are next shown in figure 3 in the process of getting out of the mother cell, after which they swim freely in the pollen tube, from which they generally escape later. In general, there are two modes by which they get out of the pollen tube, viz, (a) gradually, (b) suddenly, and this difference depends chiefly on the density of the surrounding fluid. (a) Mode of gradually escaping: Figure 4 shows an example of a spermatozoid gradually getting out of the tube, observed in Tokyo. At 4.15 p. m. (September 17) the head of the spermatozoid made its appearance a little out of the pollen tube and after five minutes it entirely got out of the tube and recovered its normal shape. Then it swam with a definite rate until 5.45 p. m. From this observation it can be seen how soft and elastic the body is. This is very similar to the escape of the swarm spores of *Œgodonium* or the spermatozoids from its old cell wall, because also in this case the shape of the swarm spore or of the spermatozoid, before and after getting out of the old cell wall, are quite different, like that of the spermatozoid of *Ginkgo*. They also have an oval shape with numerous cilia. (b) Mode of suddenly escaping: In this case the membrane of the mother cell containing the two spermatozoids (also with Hirase's two cytoplasmic cylinders?) is suddenly thrust out of the pollen tube, as shown in figure 5 xxx. At first the shape of the spermatozoid is very irregular because of the surrounding pressure produced by sudden protrusion, but gradually it separates from the mother cell and takes the form shown in *b* and *b′* and ceases its motion for a short time. Finally it recovers its complete shape, like the fruit of an eggplant, and gently begins to swim with a definite rate. This fact also shows how soft and elastic it is. In a strict sense, however, it does not always recover its former shape. For instance, when it was subjected to great pressure at the time of escaping its shape becomes like that of a snail, and in such a case after getting out it will be killed by the deformation. But even in the case of suddenly escaping, if the pressure and change in shape is not too great, it will swim freely soon after escaping.

In the case of *Zamia* the writer has given considerable attention to the method of escape of the spermatozoids and has observed the two methods described by Fujii. The first method of the gradual creeping out of the spermatozoid has been frequently observed in pollen tubes placed in sugar solution, but in almost all cases the tubes could be observed to have been broken previously, thus allowing the elastic spermatozoid to stretch out and creep through without actually penetrating the membrane itself. In very numerous instances the extreme difficulty which the unwieldy spermatozoid has in overcoming slight obstruction has been observed; as, for instance, the difficulty of breaking the plasma membrane of the pollen tube described above (p. 53). In *Zamia*, where the cellulose wall of the pollen tube is quite thick, the writer is inclined to believe that it would be impossible for them to penetrate the wall in this manner. The second mode of escape by the sudden rupture of the pollen tubes is very commonly observed. At the time of maturity the tubes seem to be under great tension and a slight touch serves to cause them to burst and discharge their contents along with the spermatozoids as described in the writer's second preliminary paper (123, p. 18). This method of escape in *Zamia* would seem unquestionably to be the one normally occurring in the process of fecundation, as described hereafter.

Which end of the spermatozoid is to be considered the anterior end and which the posterior is not an easy question to determine in *Zamia*, if analogy with other forms is disregarded. In the pollen tube and in sugar solutions they move both backward and forward, and in their rolling, tumbling motion it is hard to recognize any system. However, there are several factors which enable us to determine that the apex of the spiral must be considered as the head end: (1) The two spermatozoids as developed are attached by the side opposite the apex of the spiral, and in their separation the cilia movement always exercises a very perceptible pulling force outward toward the apex of the spiral, which gradually results in the separation of the spermatozoids (figs. 47a to 47d). (2) In general, the selective end of the spermatozoid in free motion is the spiral end. (3) In slowly creeping out of broken pollen tubes, as described above, the spiral end usually precedes, but this is not always the case. (4) As observed over the neck cells of the archegonia, apparently in the process of attempting to enter, the spiral end has always been down toward the very small opening. (5) In entering the cytoplasm of the egg cell the apex of the spiral is always in the lead, as shown by very numerous instances (fig. 56).

The last two factors are of the greatest importance, and clearly show that the spiral end must be considered the anterior end. This, of course, is what would be expected from a comparison with the spermatozoids of ferns and mosses, but it is an interesting distinction from the animal spermatozoan where the motile organ forms the tail or posterior end.

In his preliminary paper announcing the discovery of spermatozoids in *Ginkgo*, Hirase (61) described the presence of a prolongation of the posterior end of the spermatozoid into a tail, an organ not present in other plant spermatozoids, so far as known. In the writer's preliminary paper in 1897, on the spermatozoid of *Zamia* (123, p. 20), it was stated that "there is no free tail in *Zamia*, as is said by Hirase to occur in *Ginkgo*." In his complete monograph in 1898, Hirase (62, p. 123) again describes and figures the spermatozoid with a sharp-pointed tail 28μ long. He says that since one never discovers the tail in the hemispherical spermatozoids at rest in the pollen tube, it seems rational to conclude that they are formed almost at the moment of the escape from the tube end at the expense of a certain portion of the cytoplasm. Ikeno (70, p. 579) was not able to study the living spermatozoids of *Cycas*, but concluded from a study of fixed material that the spermatozoids of *Cycas* corresponded to those of *Ginkgo* in the presence of a tail. He wrote, "auch ist ein spitziger Schwanz vorhanden, welcher weiter nichts ist als die Verlangerung des hinteren Endes des cytoplasmatischen Mantels."

The writer's conclusion in regard to the absence of a tail in the spermatozoids of *Zamia* were based on a study of hundreds of spermatozoids while swimming free in sugar solution, as well as on a study of prepared material, while apparently only two living spermatozoids had been observed of *Ginkgo* and none in the case of *Cycas*. This constituted one of the fundamental points of difference between the writer's conclusions and those of Hirase and Ikeno, which would seem to indicate a closer relationship of *Cycas* to *Ginkgo* than to *Zamia*. Fortunately this difference has been explained by Fujii (39), who undertook a study of the living spermatozoids of *Ginkgo* particularly to settle this point of difference. Fujii, as described above, studied a number of living spermatozoids, and had an excellent opportunity to settle this point of difference. He concludes as follows:

> Hence, with my observations, I shall infer that the spermatozoid of *Ginkgo* has no tail. Here I will only point out that, as everyone knows, Mr. Hirase did not draw a false figure different from what he observed, and I remember that his figure is the same as one which I saw in his preparation (which was afterwards unfortunately damaged during a journey). Therefore, I think that (1) the spermatozoid in Hirase's preparation was an abnormal one; (2) when the spermatozoid was getting out of the pollen tube possibly a broken part of another cell adhered to it, and he looked upon this as a tail; (3) he may have taken a part of the body of the spermatozoid broken by pressure with the cover glass to be a tail.

In a later paper on the same subject, Fujii (40) states that deformed spermatozoids having appendages similar to that described by Hirase are quite frequently observed, being caused by pressure in escaping from the pollen tube, etc. This can often be observed in the spermatozoids in the archegonia at the time of fecundation or later. He says:

> In this case we can observe the various shapes of deformed spermatozoids, and some of them seem to have a tail or nipple or a small lump at one end of the body; * * * hence, it is not a matter of surprise if Mr. Ikeno sketched a figure of a spermatozoid at the opening of the ovisac as having a tail-like appendage, and last October I affirmed, with the preparation made by Mr. Ikeno, that a part of the mantle of this spermatozoid changed and looked something like a tail.

Since the publication of his preliminary statement that no such tail was found in the spermatozoid of *Zamia* (123), the writer has carefully reinvestigated this question, using again both living and prepared material. All the evidence which has been accumulated strengthens his former conclusion, and he is certain that no tail is present in the spermatozoid of *Zamia* under normal conditions. As explained above, however, the body of the spermatozoid is highly elastic and has a more or less pronounced amœboid movement when swimming in a confined location like the interior of the pollen tube. It is easy to see that the instantaneous killing of the spermatozoid, when a portion of the body was extended, from pressure or otherwise, might result in obtaining preparations showing tail-like protrusions. Such deformities are rarely met with, however, in *Zamia*, being evidently of much rarer occurrence than in *Ginkgo*. Ikeno's evidence supporting the occurrence of a tail in *Cycas* is evidently based on a few instances of the appearance of some such an organ on the posterior end of the spermatozoid after it has entered the archegonium. In passing through the very narrow entrance canal between the neck cells, the spermatozoids have use for all possible elasticity, as they must from necessity stretch out into a very long, slender form in making the passage. The act of passage has not been observed in *Zamia*, but the spermatozoids have been observed in many cases just after the passage. In one or two instances material has been found adhering to them which might have been interpreted as a tail had no other spermatozoids been observed. The adhering substances in these cases seemed to be from the granular mucilaginous matter in which the spermatozoids swim. Usually the spermatozoids found in the archegonia have assumed their normal form and show no suggestion of the extreme pressure they must have endured in the process of entering.

In conjunction with Mr. E. A. Bessey[1] the writer has made some interesting observations on the living pollen tubes of *Ginkgo* mounted in 10 and 5 per cent sugar solutions. The whole pollen tube apparatus is clearer and much more favorable for observation in the unstained condition than that of *Zamia*. In very many tubes the main features of the central cell could be plainly observed. The nucleus *corps sphériques* and the blepharoplasts were plainly visible when tubes were cut off and placed in sugar solutions without injury. The nucleolus could almost invariably be observed to contain at least one large vacuole, and very frequently a number of smaller ones could be observed. In one instance a nucleus was observed in a prophase of division when the chromatin had collected in a skein. This was an absolutely fresh tube and could not be mistaken, being as plain as in the fixed and stained material. The nucleoplasm outside of the skein, which was composed of large granules and presented a dense appearance, was clear and finely granular, the only difference between the skein and other nucleoplasm seeming to be the larger size of the granules in the skein and their greater density. In quite a number of cases the blepharoplast could be plainly distinguished, and in one instance shown to the writer by Mr. Bessey the contents could be seen to be vacuolated or reticular almost as plainly as in the fixed and stained material. There can thus be no doubt that the main features brought out by fixing and staining in *Ginkgo* and *Zamia* are perfectly normal and not artifacts. The study of the living material of *Ginkgo*, which should be carried much farther, promises much valuable information, particularly in confirming the results obtained by fixing and staining.

Personally the writer has made no attempt to secure the living and moving spermatozoids of *Ginkgo*, but he has fortunately been able to observe and study some of those obtained by Mr. Bessey, and can confirm the main features of the movement as described by him. The tail-like appendage which was described by Hirase certainly does not exist in the normal spermatozoids, and in the specimens observed by Hirase was doubtless due to compression in escaping from the pollen tube or some similar cause, as suggested by Fujii. The shape of the spermatozoids which have been observed by Mr. Bessey and the writer corresponds well with those figured by Hirase and Fujii. The movements of the spermatozoids of *Ginkgo* are almost exactly the same as those observed by the writer in *Zamia*. The amœboid movement of the apex of the spiral is very noticeable in *Ginkgo* also, and the rythmic motion of the cilia, similar to that occurring in *Zamia*, has been observed by Mr. Bessey.

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[1] These observations on the living material of *Ginkgo* were made on material collected by Mr. E. A. Bessey, one of the writer's colleagues. He also made many interesting observations, a short account of which will be found in Science, February, 1901.

A very interesting observation, first made by Mr. Bessey and also studied by the writer, is the rythmic vibration of a portion of the membrane at the base of the spermatozoid corresponding with the vibration of the cilia. The spot is apparently just over the "*corps sphérique*," and may have some relation to that body.

PROCESS OF FECUNDATION.

While the spermatozoids have been maturing, the proximal ends of the pollen tubes, as described above, have been growing down through the tissue of the nucellus into the archegonial chamber above the archegonia. When all of the organs are developed ready for fecundation the pollen tubes hang down so that the ends almost or quite touch the neck cells of the archegonia, which protude into the same cavity. It is interesting to note that the pollen tubes when they enter the archegonial chamber (endosperm or prothallial cavity), which seems to be filled simply with moist air, do not grow at random, but bend slightly outward and grow directly toward the neck cells of the archegonia. Frequently several were observed to grow toward the same archegonium. These observations can be made on living material by carefully cutting into the archegonial chamber at one side, without injuring the tubes, and observing them with a hand lens. The end of the tube is occupied by the spermatozoids and the vegetative cells of the male prothallus. It is probable that the spermatozoids normally begin swimming in the tubes before the latter burst, as they have several times been observed swimming in the unbroken tubes. The end of the pollen tube is wider than the upper portion and is evidently under considerable tension. The protruding tip formed by the old pollen grain (figs. 47 and 51) is plainly visible with a hand lens, and is evidently the point which first comes in contact with the neck cells of the archegonium. The neck cells are also distended and turgid and are evidently easily broken. If in this distended condition the end of the pollen tube be touched very lightly with the flat side of a scalpel it bursts, and the spermatozoids, together with a drop of the watery contents of the pollen tube, are quickly forced out and the pollen tube immediately shrivels up into a shapeless mass. This the writer thinks is what happens in the normal course of fecundation. The pollen tube evidently grows down until the end is forced against the neck cells, when the tube bursts, discharging the mature spermatozoids and the watery contents of the tube, which supplies a drop of fluid in which the spermatozoids can swim. Some doubt exists as to whether the pollen tube supplies all of the fluid in the archegonial chamber at the time of fecundation or whether some of it is extruded by the egg cell.

Hirase (62, p. 122) described the occurrence of a sap filling the archegonial chamber at the time of fecundation, and considered that it was very probably a product of the female organ. No evidence is given, however, to show that this is the case. Ikeno (70, p. 583) also thinks that the fluid is largely a product of the female organ. He says:

> I have often met with cases in *Cycas* in which fluid was already present, in spite of the fact that all pollen tubes were yet entirely intact; so that we are led to the conclusion that at least a part of this fluid—probably the larger part—proceeds from the female organ.[1]

If Ikeno was not mistaken in his observation, he is certainly correct in claiming that the female organ furnishes part of the fluid. In *Zamia*, however, the writer has frequently observed that the numerous pollen tubes are in various stages of development. One tube may have the spermatozoids swimming about in it, while in an adjoining tube the central cell has not yet completed its division. When a tube has burst and dicharged its spermatozoids it shrivels into an unrecognizable, small, and almost indiscernible mass. Tubes in an advanced stage may burst and leave a liquid in the archegonial chamber, while other tubes remain entire. In *Zamia* a portion of the fluid is certainly furnished by the pollen tube. Whether any of it is furnished by the female apparatus the writer has been unable to positively determine. It may be so, but the neck cells remain turgid and fresh up to the very time of fecundation, and no indication of the beginning of the exudation of a fluid has been observed, though it would seem that an abundant opportunity has been furnished for observing such an exudation if it occurs.

The writer has several times observed the spermatozoids after they were discharged over the archegonia, but studying them in this position is unsatisfactory and difficult. They have been observed to swim to the neck cells and stop over these and continue to gradually revolve around and around, apparently in the process of crowding into the egg cell. In fecundation the entire spermatozoid unchanged swims into the egg cell, passing between the ruptured neck cells. The entrance tube is very narrow compared with the size of the spermatozoid, and the latter must be greatly stretched out in accomplishing the passage. It is certain that they pass through into the egg cell entire, as they have in many instances been found in the egg cell having their normal shape. Several spermatozoids commonly enter each egg cell, two and three having been found in very many instances. Only one of these takes part in fecundation, and the others may be found presenting a perfectly normal appearance or in some stage of disintegration. Those not concerned in fecundation may usually be found in the upper part of the egg cell between the wall and the cytoplasm, which is slightly contracted away from the wall in the majority of the writer's preparations. In some instances they seem to have crowded against the cytoplasm of the egg and caused a noticeable indentation (figs. 55 and 70). Occasionally one of the spermatozoids not concerned in fecundation pushes for a short distance into the contents of the egg cell, but such spermatozoids do not mingle with the protoplasm of the egg cell, as they are always found in such cases to form distinct bodies, which stain very differently and remain intact until long after fecundation has taken place. The spermatozoid which reaches the egg cell first would seem to be the one which causes fecundation. That one which is utilized in fecundation swims into the cytoplasm of the egg cell for a short distance, where it comes to rest and undergoes change. The nucleus slips out of its cytoplasmic sheath and passes on alone from this point to the egg nucleus, with which it unites. The spiral ciliferous band, which forms such an interesting part of the spermatozoid, remains at the apex of the egg cell in the place where the nucleus left it. In very numerous instances just after fecundation it has been discovered in this position, and there can be no doubt that this process is the one normally occurring. It shows very plainly and presents nearly the original form of the spermatozoid, but is always stretched out much more than in the normal spermatozoid. The band lies free in the cytoplasm of the egg cell, and the sections of the spiral, with the numerous cilia radiating from them, are frequently very distinct and can be easily photographed (fig. 69).

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[1] Ich habe bei *Cycas* oft Fälle angetroffen, in denen eine Menge Saft schon in der Endospermhöhle vorhanden war, wenn auch alle Pollenschläuche noch ganz intact waren, so dass wir zu der Annahme geführt werden, dass wenigstens ein Theil dieses Saftes—wahrscheinlich der grösste Theil—aus dem weiblichen Organe herstammt.

The method of the escape of the nucleus from the body of the spermatozoid can only be conjectured. It would seem, however, that the rapid boring of the apical or spiral end into the egg cell may cause too great a pressure on the large body of the spermatozoid, resulting in its bursting and freeing the nucleus, while the cilia motion continues probably some time longer, carrying the band farther along and freeing the nucleus from any hindrance by it. The apex or spiral end of the spermatozoid invariably enters the egg cell first, and in all of the cases observed where the nucleus has just escaped from the spermatozoid it has been found a short distance behind the spiral of the spermatozoid, as if it had been forced out and left behind (fig. 54). The function of the cytoplasm of the spermatozoid is still in considerable doubt, but that it fuses with the cytoplasm of the egg cell is certain. Shortly after the nucleus has broken out of the spermatozoid cell the thin layer of dense cytoplasm which surrounded it can be seen in a broken, fragmentary form, still somewhat connected with the spiral band (fig. 57). The cytoplasm of the spermatozoid in this stage is very different from that of the egg cell, being more densely granular and staining more deeply, so that it is easily distinguished. Later only a rather coarse granular substance is found inside of the spiral coil of the ciliferous band, and it would seem that this is the cytoplasmic matter from the spermatozoid which has mingled with that of the egg cell. It should be mentioned that the plasma membrane surrounding the spermatozoid has entirely disappeared, no trace of it being visible. It would seem to have fused with some substance of the egg cell or to have been absorbed in some way.

No case of polyspermy has been observed in the specimens examined. In no instance has more than one empty spiral been found in the same egg cell. Where an empty spiral was found it could be predicted that the egg nucleus would be found to have been fecundated; and, vice versa, when a fecundated egg nucleus was found it could be predicted that an empty spiral ciliferous band would be found at the apex of the cell. No exception to this rule was observed in the very large number of specimens examined.

The male nucleus, when it has escaped from the spermatozoid and is observed lying in the cytoplasm at the apex of the egg cell, is of loose, open structure, seeming to have but little kinoplasmic and chromatin matter. The passage to the nucleus is evidently a rapid one, as few stages have been found between the above and the completion of fecundation. In some instances the path over which the nucleus traveled in reaching the egg cell is discernible by the arrangement of the granules in the cytoplasm, showing the direction of the passage (figs. 55 and 56).

The egg nucleus previous to fecundation is elliptical and is located slightly below the center of the enormous egg cell, which is about 3 mm. long by 1.5 mm. wide. The egg nucleus is of enormous size, comparatively, being plainly visible to the unaided eye. It is composed of an open, coarse reticulum (fig. 54). So far as the writer has observed, there is no depression or "empfängnisshöhle" in the upper part of the nucleus where the sperm nucleus enters, as was found by Ikeno in *Cycas* (70, p. 585). No special attention has been given to this matter, however, and further observation may show it to be present. The male nucleus in entering the egg nucleus gradually pushes into it, as observed by Ikeno in *Cycas*, and finally becomes entirely surrounded by it. Meanwhile it has changed its structure and become densely granular, differing markedly from the egg nucleus in this particular. Considerable search has been made for indications of extrusions of matter from the sperm or egg nucleus at the time of fecundation, such as has been described by Ikeno in *Cycas* (70, p. 587). No indications of such extrusions have been found, however. After fecundation is apparently completed, the male nucleus appears as a small, nearly round body in the upper portion of the egg nucleus into which it has penetrated. The further changes in the male and female nuclei before they undergo division have not been followed.

The isolated ciliferous band lying free in the protoplasm at the apex of the egg cell evidently retains its identity for a considerable time. It has been observed in several instances after the formation of many free nuclei by the repeated divisions of the oosphere. Frequently the spindles of some of these free nuclei in division have been observed between its spirals. The band ultimately disappears, its substances probably being consumed by the forming embryo. The primary function of the ciliferous band thus certainly ends with the transporting of the male germ cell from the pollen tube to the egg cell, as was first shown by the writer in October, 1897 (124). The same process of fecundation was later described by Ikens as occurring in *Cycas* (69). The exceptional size of the spermatozoids and egg cell in *Zamia* permits these features to be seen very plainly. While in the majority of plants in which the entrance of the spermatozoids has been studied, they are so small that thus far the fate of the cilia and cytoplasm, which are not generally supposed to be concerned in fecundation, has not been determined with very great certainty. In *Fucus* Strasburger (111, p. 363) has concluded, judging mainly from comparative size, that shortly after the entrance of the spermatozoid its cytoplasm unites with that of the egg cell and only the nucleus continues its passage and unites with the egg nucleus. Shaw's studies of the fertilization of *Onoclea* (103) indicate that in fecundation the cytoplasm and cilia-bearing band remain in the cytoplasm of the egg cell, but this was unfortunately not definitely determined. It is interesting to note further in this connection that the spermatozoid nucleus in *Onoclea* unites with the egg nucleus without any change of form. Thom's study of the process of fertilization in *Aspidium* and *Adiantum* (115) is also very interesting in this connection. It would seem from Thom's investigations that commonly the entire spermatozoid enters the egg nucleus, although this is not made plain, as it is stated that "the cytoplasmic forward end contains, or is partially derived from, the so-called blepharoplast, and bears numerous long cilia. This part either becomes disconnected entirely before the spermatozoid reaches the egg, or, becoming functionless, is turned backward and dragged passively along into the cytoplasm of the egg."

This would seem to confirm the writer's statement that the blepharoplast is an organ developed primarily for the transportation of the male nucleus, but the discrepancy between the question of fusion of cell parts is very noticeable. In *Zamia* and *Cycas* the entire spermatozoid invariably enters the egg cell and the cytoplasm and ciliferous band (blepharoplast) fuse with the cytoplasm of the egg, while the nucleus journeys on to the egg nucleus, with which it fuses. A number of investigators, the writer has noticed, seem to conclude that because the nucleus of the spermatozoid travels on alone and fuses with the egg nucleus the nucleus alone is concerned in fecundation. It may be that the nucleus is the sole bearer of hereditary tendencies and that this is the important part of fecundation. The fact remains, however, that in *Zamia* and *Cycas* and those cases of fecundation that are best known there is a fusion of cells, nucleus with nucleus and cytoplasm with cytoplasm, as would be naturally expected. We could hardly expect the entire spermatozoid nucleus and cytoplasm to fuse with the egg nucleus. It would seem as though the cytoplasmic envelope figured by Thom, as left by the spermatozoid in the cytoplasm of the egg cell after the nucleus has escaped, must contain the ciliferous band, if, indeed, it is not made up almost entirely of the band. From analogy with *Zamia* and *Cycas* this would immediately be supposed to be the ciliferous band of the spermatozoid, the nucleus having united with the egg nucleus and the cytoplasm with the egg cytoplasm.

In the Gymnosperms, according to Blackman, Murrill, and others, it is an entire cell that takes part in the fecundation, but no blepharoplast is here present. Dixon (27) was the first to observe in *Pinus sylvestris* that all four nuclei from the pollen tube—the two generative nuclei, the pollen tube nucleus, and the nucleus of the stalk cell—passed over into the egg cell in fecundation. Blackman (16) confirmed this conclusion in his study of *Pinus sylvestris*, and further stated that "it can not be doubted that cytoplasm also passes over into the oosphere, for each generative nucleus in the pollen tube is clearly surrounded by its own layer of cytoplasm, as can be observed in the stage when the tube is clearly in contact with the oosphere." Murrill, in his study of *Tsuga canadensis* (91), claims that the contents of the pollen tube "cast into the egg consists of two sperm cells, the stalk cell, the vegetative nucleus, and some protoplasm and starch from the tube cavity." The sperm cells are described as having dense cytoplasmic contents and large nucleus. The process of fecundation described by Murrill compares exactly with what the writer had previously described in *Zamia* (124) and what Ikeno found in *Cycas* (70). Murrill says:

> It is through the first sperm nucleus that fertilization is accomplished. A short time after its entrance into the egg it slips from its cell and moves with accelerated velocity toward the egg nucleus, the latter remaining stationary and inactive.
>
> * * *

In the case of the spermatophytes also some recent investigators are claiming that the male germs which pass over into the egg cell are true cells and not simply nuclei. The discovery of the spermatozoids of *Ginkgo*, *Cycas*, and *Zamia*, and the demonstration of the action of these enormous spermatozoids in fecundation, has had much to do in clearing up our ideas of fecundation, as it was in *Zamia* and *Cycas*, where for the first time it was positively shown in plants that an entire male cell entered the egg and the cytoplasm fused with the cytoplasm of the egg cell, while the nucleus traveled on and fused with the egg nucleus.

At the time of fecundation in *Zamia*, before the formation of the primary spindle has begun, so far as can be told, a very peculiar condition of the cytoplasm is observed throughout the enormous egg cell. The entire kinoplasm of the cell seems to collect in little comet-like figures here and there throughout the cell, presenting a most remarkable appearance (fig. 69). This condition is observed in sections stained by both the Flemming and the Haidenhein methods. Sections showing this polarized condition of the kinoplasm were exhibited at the meeting of the British Association for the Advancement of Science, at Toronto, Canada, in 1897, and excited interesting comments. The kinoplasmic rays here seem to run together at one point, but there is no differentiated body occupying this point upon which they are focused. There seems to be no regular direction in which the rays extend. They are here and there and all over, throughout the egg cell, without any regularity. They can not come from the broken-down ciliferous membrane, as it still remains perfectly intact at the apex of the egg cell. They can not be fragments of the spindle resulting from the division of the canal cell, for they are never observed previous to fecundation. Chamberlain (21, p. 277, figs. 8 and 32) illustrates cytoplasmic comet-like figures in the egg cell of *Pinus larico* much like those which the writer has found in *Zamia*, but he thinks them to be broken-up portions of the spindle formed in the cutting off of the ventral canal cell. This the writer thinks is certainly not their origin in *Zamia*. Their function also remains in doubt, but it would seem probable that they have some important function in the formation of the first segmentation spindle.

DIVISION OF THE FECUNDATED EGG CELL.

In establishing the complete history and nature of the blepharoplast it is of special interest to determine whether it has any important function in the division of the fecundated egg cell. If it is a centrosome, as claimed by some writers, does it function as a centrosome in the segmentation of the egg? It seems to have been established that in many animals the spermatozoid brings in the centrosome which forms the amphiaster for the first division, but this has not yet been proved in the case of any plant. That the blepharoplast or the cilia-forming organ enters the egg and remains in the cytoplasm in *Zamia* and *Cycas* is certain and not open to any question.

The writer has endeavored by diligent search to observe the formation of the first segmentation spindle, but thus far has been unable to succeed. However, he has been able to observe the spindle in the second division which leads to the formation of four daughter nuclei. Here the spindle is of normal form, but rather drawn out at the poles. No differentiated body can be observed at the poles of the spindle which could be considered a centrosome. In the later divisions also very many dividing nuclei in various stages have been carefully studied, but without success. In no case of dividing nuclei in the early cleavage divisions before the seed matures has any centrosome been observed. This statement corresponds entirely with the writer's earlier conclusions reached in 1897 (124). In the case of *Ginkgo* and *Cycas* also, according to the researches of Hirase and Ikeno, no centrosomes or centrospheres could be found in the early divisions of the egg nucleus.

Aside from this very conclusive evidence that the blepharoplast brought in by the spermatozoid does not form a centrosome which takes part in the formation of the first segmentation spindle, the conclusion is indubitably established furthermore by the fact that the ciliferous band remains intact at the apex of the egg cell for some time following the division of the egg nucleus. It has been observed unbroken after at least five or six divisions when the daughter nuclei had become spread here and there in the egg cell. In several instances nuclei resulting from the division of the egg nucleus have been found occupying a position between the spirals of the ciliferous band. This was very puzzling when first discovered before the development was understood.

The division of the egg nucleus results in a decided reduction in the size of the nuclei until they are reduced from the tremendous size of the egg nucleus, which is visible to the unaided eye, to rather small nuclei not above an ordinary size. The first two or three divisions take place while the nuclei remain grouped together in the center of the egg cell in the position of the original egg nucleus; after this the nuclei become gradually scattered throughout the egg cell and finally, in the first stage of the organization of the embryo, form a layer of cells around the periphery of the egg cell. The history of the formation and development of the embryo, however, has no place in the present memoir. The writer will discuss this matter at some future time in another place.

IS THE BLEPHAROPLAST A CENTROSOME?

The feature of most interest in this investigation is the question regarding the true nature of the blepharoplasts or cilia-forming organs of the spermatids. When these organs were first observed in *Ginkgo* by Hirase in 1894 (57) he referred to them as attractive spheres, as would naturally be done by anyone unfamiliar with their complete history. The next reference to them in literature occurs in the writer's first preliminary paper published in June, 1897 (122), in which their centrosome nature is questioned. In the writer's third preliminary paper, which appeared in October, 1897 (124), it was shown for the first time that the bodies in question originate *de novo* in the cytoplasm of the central cell, apparently having no important functions in the formation of the spindle, when this cell divides to form the spermatids, and after it has served its function in forming the cilia of the spermatozoid it disintegrates at the apex of the egg cell, apparently having no further function. For these reasons it was concluded that the organs were not centrosomes proper, and they were termed *blepharoplasts*, because of their special function as cilia-formers. This immediately led to controversy, and the question is still unsettled. Early in 1898 Ikeno (69, p. 17) stated unreservedly that the centrosome-like body in Cycads and *Ginkgo* is a true centrosome. He said:

> If we apply this conclusion of Hermann to our case, then it is quite clear that the body in question, which corresponds to the middle piece in serving as the cilia-bearing thread, is not only similar exteriorly to a centrosome, but is a true centrosome, and that the cilia-bearing thread is to be regarded as an enormously enlarged centrosome.[1]

This opinion is further emphasized by Ikeno in his complete monograph on the fecundation of *Cycas revoluta* (70). Hirase, in his study of *Ginkgo* and the attractive spheres formed in the spermatogenous cells, also concludes that they are to be considered as centrosomes, though, as shown by his figure 18 (61, pl. 8), they remain distinct from the spindle, the radiations around the sphere not connecting with the radiations around the pole of the spindle in the center of which a centrosome should be located, if present. Hirase says, furthermore:

> The attractive spheres which we have just described are different from those made known by many scientists heretofore. In the first place, they differ in that they are always at a certain distance from the poles of the spindle, and in the second place that in the course of karyokinesis they do not divide into two daughter spheres.[2]

Guignard also takes the same ground, considering the writer's researches on *Zamia* as proof of the existence of centrosomes in seed plants. He says:

> Even though all earlier observations upon the presence of attractive spheres and centrosomes in different Cormophytes may be regarded as inexact, one can not doubt that the bodies recently described and figured by Webber in the pollen cells of *Zamia* * * * are centrosomes (48, p. 161).

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[1] Ueberträgt man diese Hermannische Folgerung auf unseren Fall, so ist es ohne Weiteres klar, dass der in Rede stehende Körper, welcher sich zum Mittelstück entsprechenden cilientragenden Faden ausdehnt, nicht nur äusserlich einem Centrosom ähnlich, sondern ein wahres Centrosom ist, und dass der cilientragende Faden als ein enorm herangewachsenes Centrosom zu deuten ist.

[2] Les sphères attractive que nous venons de décrire sont différentes de celles signalées jusqu'à ce jour par plusieurs savants, en premier lieu, en ce qu'elles sont toujours à une certaine distance des pôles du fuseau, et en second lieu en ce qu'au cours de la karyokinèse elles ne se divisent pas en deux spheres-filles.

Balajeff also, in his recent researches on *Marsilia*, concludes that the blepharoplast must, from its position and relation to the achromatic spindle, be considered a centrosome. He says:

> In this manner the stainable corpuscles possess all the peculiarities characteristic of the centrosomes, not only as a result of their position at the poles of the spindle, but also through their relation to the achromatic threads.[1]

Practically the same conclusion in regard to the homologies of the blepharoplast is reached also by Chamberlain, who states it thus:

> It seems probable that a thorough investigation of karyokinesis and the formation of cilia in the lower plants may support the theory that the blepharoplast is a centrosome (20, p. 434).

E. B. Wilson also regards the blepharoplast as the homologue of a centrosome or centrosphere. He says:

> The later studies of Shaw (102) and Belajeff (14, p. 199) on the blepharoplasts in *Onoclea* and *Marsilia* leave no doubt that these bodies are to be identified with centrosomes (130, p. 175).

The writer in his studies has not been blind to the fact that the bodies in question resembled the centrosomes or centrospheres which have been described by some authors, both in external appearance and function. Our idea of the centrosome as a permanent *sui generis* organ of the cell, having as its prime function the governing and controlling of cell division, has become so modified in the last few years that it is hardly possible to define what constitutes a centrosome. It seemed to the writer that it was high time that organs resembling a centrosome which could be proven to have very definite and distinct functions from the centrosome as ordinarily understood should be given distinct names, whether or not they can ultimately be traced back and found to be homologous organs. We do not call the supporting tendril of the Virginia creeper a leaf, nor the leaf a tendril, yet they are clearly homologous organs. It was from this standpoint that the writer was willing to brave the odium of introducing another new term to our already crowded vocabulary. The blepharoplast, it is true, may ultimately be proved to be the homologue of a centrosome, and the writer forcibly called attention to this possibility at the Ithaca meeting of the American Society for Plant Morphology and Physiology, held in December, 1898. Even if this were true, however, which the writer is still inclined to doubt, it would nevertheless be necessary to have a distinguishing term, as the organ has now assumed a specialized function different from the original. The writer's view that the blepharoplast is probably a distinct organ from the centrosome has received the support of Shaw (102), Mottier (89), Strasburger

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[1] Auf diese Weise besitzen die färbbaren Körperchen nicht nur in Folge ihrer Lage an den Polen der Kernspindel, sondern auch durch ihre Beziehungen zu den achromatischen Fäden alle Eigenthümlichkeiten, welche den Centrosomen charakteristisch sind, sie müssen daher als solche betrachtet werden (14, p. 202).

(112, p. 185 *et seq.*), and Studnicka (113), whose conclusions will be mentioned in some detail later on. Before stating these, however, it will be well to compare the blepharoplasts of the Cycads, *Ginkgo*, and ferns with some of the cases of typical centrosomes and centrospheres. An exhaustive comparison would extend this paper beyond its desired limits and would be of questionable value, because the centrosome question as a whole is in too great confusion to allow any final conclusion to be reached.

One of the most typical cases of centrosomes in plants is that described by Swingle in 1897 as occurring in *Stypocaulon* (114). Here a minute, deeply staining, dumb-bell-shaped body occurs at the pole of the spindle in karyokinesis, which at the close of division divides into two. Both of these remain in close connection with the nuclear membrane, but travel in opposite directions until they come to lie at opposite points on the equator of the nucleus. They are always surrounded by rays of kinoplasm, which become very abundant during spindle formation and division and are not surrounded by any differentiated sphere of any sort, as so commonly occurs in the centrosomes of animals. In spindle formation the centrosome appears to be of prime importance, a bundle of fibers starting from each centrosome and gradually extending into the nucleus until the spindle is completely formed. Swingle's studies were made with growing vegetative tips, which would indicate that the centrosome here is probably a permanent organ in all stages of growth. Centrosomes of almost exactly the form of those of *Stypocaulon* have been described by Strasburger (111) in *Fucus*. A very distinct deeply staining centrosome is described, which he believes to be a permanent organ of the cell, reproducing by division at the end of each nuclear division, thus forming two which control the next division. The observations of Farmer and Williams (37) are also of interest in this connection. They describe very marked centrospheres at the poles of the spindle of *Fucus*, in which an irregular number of granules, possibly representing centrosomes, can be observed. The number and general character of these granules is not uniform and the writers do not attach any significance to them. The centrospheres could not be traced through the resting cell, and are apparently originated *de novo* at each period of nuclear division. The relation of the centrospheres to spindle formation was not traced out in detail, but its connection with the mature spindle and later stages of division is unmistakable. In fecundation no visible centrosphere is brought into the egg by the spermatozoid, and Farmer and Williams find no support for the statement of Strasburger that an apparent connection can be traced between the position of the two centrospheres of the dividing egg and the limits of the portion of the oospore nucleus which belonged to the sperm. The connection of the centrosphere with cilia formation in the spermatozoids of *Fucus* has not been traced out, but it is certain that the centrospheres occur here before and after fecundation in connection with spindle formation and karyokinesis, and are not simply cilia-forming organs of the spermatozoids, if indeed they can be in any way identified with such a function.

In *Dictyota*, also, Mottier (89 and 90) has demonstrated the occurrence of centrosomes similar to those described in *Stypocaulon* by Swingle, and in *Fucus* by Strasburger. They are small, deeply staining bodies, located in the center of a large aster, and are apparently permanent organs of the cell, reproducing by division during the reconstruction of the daughter nucleus. The centrosomes here also are intimately connected with spindle formation, as in the case of *Stypocaulon*, the fibers growing into the nucleus from each centrosome in forming the spindle. In the above three cases, *Stypocaulon*, *Fucus*, and *Dictyota*, there is a great uniformity of the centrosomes and their action and appearance, and they are by all means the best worked out, most definite, and positive cases of centrosomes known to occur in plants, though many other cases of centrosomes and centrospheres, etc., have been described. To these the blepharoplasts of *Zamia* have only a very indistinct resemblance in being located at the center of a group of radiations. In all essential features they are totally distinct.

In the division of the tetrospore of *Dasya* Davis (25) has described the occurrence of a body at the pole of the spindle which is supposed to be a centrosome or centrosphere which in one stage is broken up into a mass of granules, in this regard resembling the blepharoplasts of *Zamia*. In other ways and in function they are apparently very distinct organs from the blepharoplasts.

In the fungi several cases of well-authenticated centrosomes or centrospheres have been described, but all of them are very distinct from the blepharoplasts of *Zamia* and the Cycads. In the nuclear division in the ascus of *Erysiphe* Harper, in a brilliant contribution, has described the presence of a centrosphere which takes part in the formation of the plasma membrane of the spore. In the nucleus just previous to division, the centrosphere forms a flattened disk attached to the nuclear membrane. Later this disk becomes surrounded with numerous radiations. The division of the centrosphere has not been observed here, but stages slightly before the division, when the two daughter centrospheres are still near together, are figured by Harper (51, p. 251, figs. 4, 5, and 6). The centrosphere here would seem to be a permanent organ of the cell, increasing by division, but this is yet uncertain. Its connection with spindle formation is plainly evident, the fibers growing into the nucleus from it toward the chromosomes and finally forming the spindle. In spore formation in the ascus the centrosphere was found by Harper to have the novel function of forming the plasma membrane delimiting the spore in the ascus, a method of free cell formation which has been observed in no other place, so far as the writer is informed. This is accompanied by a neck extending out from the nucleus at the point where the centrosphere is located, the centrosphere being extended away from the main body of the nucleus farther into the cytoplasm. When this neck or beak has reached its definitive length the kinoplasmic rays all bend downward and come to lie in a plane parallel to the nuclear wall and fuse together, forming a bell-shaped membrane surrounding the nucleus, with the centrosome forming its apex. By the growth of this membrane the nucleus is finally entirely surrounded, together with a portion of the cytoplasm of the original ascus, and the ascospore delimited. The same process of free cell formation in the delimiting of spores in the ascus has also been carefully described by Harper as occurring in *Lachnea* and is probably a common method of spore formation in asci. The extension of the beak from the nucleus which remains in connection with the centrosphere while the kinoplasmic rays from the latter fuse together and form the plasma membrane delimiting the ascospore, is similar to the beak from the nucleus of *Ginkgo* and *Cycas* which Hirase (62) and Ikeno (70) have found to remain in connection with the blepharoplast while it is extending in length and forming the cilia of the spermatozoid. This beak connection also recalls the beak of the nucleus which extends out to the *Mundstelle* on the plasma membrane of the cell in the formation of the cilia of the swarm spore of *Vaucheria* as described by Strasburger (112, p. 188). That there is an analogous relation between the nucleus and the centrosphere, blepharoplast, and *Mundstelle*, respectively, in the three cases can not be questioned.

In the Hepaticæ centrospheres have been described by Farmer (33) as occurring during spore formation. They form the center of a series of radiations, and do not become visible until the radiations are fairly well developed. The center of the system of radiations was not always occupied by a single granule or centrosome; often several distinct granules were visible, forming a microcentrum in the Heidenhain sense. The centrospheres disappear at the close of the division, and before each division are apparently originated *de novó* in the cytoplasm of the cell in close relation to the nuclei. The interesting feature in connection with the centrosomes here and the blepharoplasts in *Zamia* is that they are supposed to originate *de novo* in the cytoplasm of the cell. Studies of spermatogenous cells of the Hepaticæ would doubtless prove of special interest, as a genuine centrosome being present in the divisions during spore formation may also be expected to occur in these divisions as well.

The cases of centrosomes among higher plants, or spermatophytes, are all as yet open to some degree of doubt. Various authors have claimed to have found special granules at the poles of the spindle, and that this is the case can hardly be questioned. In the divisions leading to the formation of the pollen in *Nymphæa*, *Nuphar*, and *Limo-*

dorum, Guignard (49) describes the occurrence of definite granules at the poles of the spindle which seem to be similar to centrosomes. He claims that the occurrence of multipolar spindles can not be taken as evidence of the nonoccurrence of centrosomes, as the multipolar spindle in which a definite granule may occur at each pole evidently later becomes bipolar by the various polar ends of the spindle swinging around together and uniting in such a manner as to form a normal bipolar spindle. Schaffner also claims to have found bodies which he calls centrosomes at the pole of the spindle in *Sagittaria* (99), and in root tips of *Allium cepa* (100). Fullmer also claims to have found centrosomes in the seedlings of *Pinus larico* and *P. sylvestris* (41). Even considering the claims of Guignard, Schaffner, and Fullmer for the presence of a centrosome in certain Spermatophytes, their occurrence is still a question of grave doubt. The very careful and complete researches of Osterhout (94), Mottier (87, 88, etc.), and many others, where no indication of a centrosome has been found, throw a doubt on the matter, and their presence must be confirmed by other investigators in those plants where they are said to occur before their normal and regular occurrence can be credited. They must be of such a nature that they can be demonstrated to occur in the same species of plant in the same stage of development by various investigators. If we are to recognize evanescent bodies as the homologues of centrosomes, our whole idea of the importance and nature of these organs must change.

Our conception of the centrosphere and centrosome is continually changing. The original idea of Boveri (17) that the centrosome is "a distinct, permanent cell organ, which, increases by division and supplies the dynamic centers for the succeeding cell formations,"[1] has been greatly modified by the extensive researches of recent years. It is no longer looked upon as a necessary cell organ reproducing itself by division, a number of instances being known where they are formed *de novo* in the cell. Various forms are also known, so numerous that there seems to be almost no correspondence between them; still there are certain morphological characteristics and certain functions which may be said to be common to all centrosomes. The centrosome or centrosphere, in its typical sense, as the writer understands it, is an organ of the cell, with the following attributes: (1) It is located in the center of an aster, at the pole of the spindle during division; (2) it has, as its special function—the formation of the spindle and the control of the division; (3) it occurs usually, at least, in the division of sexual and embryonic cells.

In regard to the first of these propositions the writer is not aware that any cell organ, which never forms the center of an aster at the pole of the spindle, has been considered by any investigator as the homologue of a centrosome. An exception, of course, must be made in the case of the blepharoplasts of *Zamia*, *Cycas*, and *Ginkgo*, which are under discussion, if we accept the statement that they are at the poles of the spindle. The blepharoplasts of *Marsilia*, according to Belajeff's investigations, are located at the pole of the spindle, but, judging from his figures, they are not located in the center of an aster.

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[1] "Ein der entstehenden Zelle in der Einzahl zukommendes distinktes dauerndes Zellenorgan, das, durch zweitheilung sich vermehrend, die dynamischen Centren für die Entstehung der nächst zu bildenden Zellen liefert" (17, p. 60).

In regard to the second proposition, it may be stated that in all of the well-worked-out cases in plants where centrosomes or centrospheres occur, as in *Sphacelaria*, *Dictyota*, *Fucus*, Hepaticæ, etc., the centrosome is of prime importance in spindle formation. There are, of course, cases which have not been thoroughly studied where this is not known to be the case. While this statement would hold true in general with animal cells, the writer is not sufficiently familiar with the literature to discuss the possible exceptions.

As to the third proposition there is a very great difference in different cases. The original idea of Boveri that the centrosome is a necessary and permanent *sui generis* organ of the cell, passing from cell to cell in division, has probably been abandoned by all investigators of the present day. It is claimed in various plants and animals to originate *de novo* in the cell, or at least become visible only at certain stages and in certain tissues. However, in all cases of genuine centrosomes known to the writer, they occur regularly in the cell divisions of certain tissues and seem to be mainly concerned with the spindle formation and division, having this as their prime if not sole and only function.

Considered in comparison with the above-described attributes of a centrosome, the blepharoplasts of *Zamia*, *Cycas*, and *Ginkgo* would seem to be very distinct organs. In *Zamia* the blepharoplast is located in the center of a very noteworthy aster, but when the spindle is formed there is found to be no connection between this and the blepharoplasts, which are located some distance outside the pole of the spindle. The same feature is very noticeable in *Cycas*, judging from Ikeno's figures 25a and 25b (70), and in *Ginkgo*, judging from Hirase's figures 18 and 19 (62).

The blepharoplast of *Zamia* has no discernible part in spindle formation, and it is certainly not a spindle-forming and division-directing organ. In no stage of the division have the spindle fibers any connection with it. The same can be said of *Cycas* and *Ginkgo*, so far as can be told by the investigations of Ikeno and Hirase. In *Ginkgo* in particular Hirase (62, fig. 18) figures an aster at the pole of the spindle inside of which a centrosome should be located, if present. The blepharoplast with its radiations, however, is located in the cytoplasm outside of this, the rays having apparently no connection.

In *Marsilia* the matter is more doubtful. Belajeff investigated the spermatogenesis of *Marsilia* particularly to determine the relationship of the blepharoplast to spindle formation, and he describes it as occurring at the pole of the spindle, thus fulfilling the requirement of position for a centrosome. Figures are given illustrating numerous spindle fibers extending from the nucleus to the blepharoplast, in the early stage of spindle formation, before the nuclear membrane has disappeared. It must be admitted that if these figures are directly translated in the light of previous knowledge of the centrosome question we can hardly escape the conclusion that the bodies must serve the purpose of a genuine centrosome in spindle formation, no matter what their later function may be. It seems surprising, however, that no radiations extend out from the blepharoplast into the cytoplasm on other sides than toward the nucleus when the spindle fibers would appear from the figures to be so plainly visible. The centrosome usually forms the center of an aster, the rays of which extend out in all directions. Yet judging from Belajeff's figures there is no indication of such radiations in *Marsilia*. It would seem possible that in *Marsilia* the blepharoplast may be independent of the spindle, though occupying a position near the meeting point of the converging spindle fibers. Such a body being present in the cell and normally in close proximity to the pole of the spindle, it is not surprising that it might appear in some instance to be nearly related to the spindle. Strasburger (112, p. 198) says that the blepharoplast is active kinoplasm, and that its collection at the pole of the spindle in spermatogenous cells of *Marsilia* does not signify particularly as to its relation to the spindle threads.

The writer is well aware that the great majority of investigators would consider Belajeff's figures and investigations as conclusive evidence of the centrosome nature of the blepharoplast, and the views of this brilliant investigator must meet with careful consideration. The matter is far from settled, however. In the light of Strasburger's investigations on swarm-spore formation and the origin of the cilia in these organs from a blepharoplast, the independent nature of the blepharoplast can not be set aside without further light on the spindle formation in *Marsilia*.

In regard to the occurrence of the blepharoplasts of *Zamia* it may be said that they are of very limited duration, occurring only in the central cell, where they originate *de novo*, and enduring through the division of this and the formation of the spermatozoids. They occur thus in only a single division with which they have no material connection. After fecundation they are lost and do not appear again until the central cells of the next generation are developed in the pollen grains. The same is true also of *Cycas* and *Ginkgo*. In *Marsilia*, according to Shaw (102), bodies similar to the blepharoplasts, which he calls blepharoplastoids, occur in the division preceding that, giving rise to the central cell, and according to Belajeff (14) they appear a few cell generations earlier, but still in the spermatogenous tissue. It is easy to understand why blepharoplasts should occur in all of the spermatogenous cells resulting from the division of the central cell of the antheridium, as all of these cells may be considered potential spermatozoids. While in *Marsilia* 16 spermatids are formed by four successive divisions of the central cell, in some other species a less number of cells is formed, some of the intermediate divisions being dropped out. It seems to the writer, from analogy with *Zamia* and *Ginkgo*, where the blepharoplasts appear in the central cell, that they may be expected to occur also in the central cell of *Marsilia* and other ferns with which the central cell of the prothallum (antheridium) of *Zamia* is supposed to be homologous. It will be remembered that Moore found rudimentary cilia developing in the spermatozoa mother cells of salamander. All of the intervening cells between the central cell and the spermatids being considered as potential spermatids, it becomes evident that we should expect blepharoplasts or their rudiments to be present. The fact brought out by Shaw and Belajeff that these bodies apparently appear *de novo* in each cell generation and then at the close of the division disappear in the cytoplasm, new blepharoplasts arising meanwhile to function in the next cell generation, seems to the writer to lend strong support to his claim of the independent nature of the blepharoplast.

The evidence from the zoological standpoint would seem to entirely favor the centrosome nature of the blepharoplast, as the almost unanimous conclusion drawn in recent work on spermatogenesis indicates that the axial filament arises from a centrosome which forms the middle piece of the spermatozoid. After the exhaustive researches of Meves (82), Hermann (55), Moore (86), Benda, Lenhossek, Suzuki, McGregor, Paulmier, etc., this fact can hardly be doubted. Wilson says, in summarizing the questions of spermatogenesis in animals:

> In reviewing the foregoing facts we find, despite many variations in detail, three points of fundamental agreement, namely: (1) The origin of the sperm-nucleus from that of the spermatid; (2) the origin of a part at least of the "middle piece" from the spermatid-centrosomes; and (3) the outgrowth of the axial filament from one of the spermatid centrosomes.

Wilson (130, p. 170) also concluded, as stated above, that the cilia-forming organ in *Zamia*, *Cycas*, *Marsilia*, etc., is to be homologized with a centrosome, and the same conclusion is indicated in Henneguy's discussion of the matter (54). It would be presumptuous on the part of the writer to criticise these conclusions so far as they relate to the question of spermatogenesis in animals, and they must be accepted by him as they stand. He feels, however, that he is justified in refusing to admit, at least with the present evidence, that this must be taken as settling the matter for plants also, where the whole centrosome question is on an entirely different plane.

In connection with Strasburger's theory that the blepharoplasts of plants are derived from the cilia-forming organs of asexual swarmspores, it is interesting to note that in ordinary ciliated animal cells a small, refractive, highly stainable body is developed at the base of each cilium with which it is connected—the so-called "basal knob" which lies near the periphery of the cell. These bodies have recently been considered by Henneguy (53) and Lenhossek (78) as of the same nature as the centrosome. A recent contribution to this question by Studnicka (113) is of special interest in this connection. He has studied the position and relation of this body to the cilia in numerous invertebrates and vertebrates in different ciliated cells, and concludes that this body ("*Fussstücke*" or "*Blepharoplast*") can not be surely identified with a centrosome. It is of special interest that in very many instances he found centrosomes near the blepharoplasts in the same cell (in *Salamandra maculata* and *Petromyzon fluviatilis*). It logically follows from this, as he states, that it "is hardly justified to always see in blepharoplasts specialized centrosomes." It would follow from this, if the basal knob can be considered a blepharoplast, that they can exist independently in a cell near the centrosomes, from which it follows that they can also appear in cells where no centrosomes exist.

In tracing the derivation of the blepharoplasts it may be argued that while the centrosome is not at present developed normally in the various tissues of the Cycads, *Ginkgo*, etc., at one time they were formed normally in the various tissues, and in the course of phylogenetic development have been gradually eliminated from the plant in general, being preserved and specialized only in the case of the spermatogenous cells where they serve an important and special function. No evidence has as yet been brought forward, however, on which such a conclusion can be based. Strasburger's recent researches (112) are of the greatest importance in pointing out the possible derivation of the blepharoplast from organs other than centrosomes. He takes the view that the blepharoplasts of *Zamia*, *Ginkgo*, etc., are homologous to the cilia-forming organs of swarmspores in lower plants, and have been derived from them. In the formation of the swarmspores in *Vaucheria*, *Œdogonium*, *Cladophora*, etc., Strasburger has found that the nuclei approach the plasma membrane of the cell, toward which it becomes somewhat stretched out in the form of a beak. At the point where the nuclear beak or extension touches or approaches the plasma membrane a lens-shaped thickening of the membrane occurs from which the cilia are developed, a small knob being discernible at the base of each cilium. It has been thought that each of these knobs might represent a centrosome, but if so, they would be numerous and difficult to account for. No connection has been traced either between these numerous basal knobs of the cilia or the entire lens-shaped body from which they develop and a centrosome existing in previous cell divisions. In the case of *Œdogonium*, furthermore, as pointed out by Strasburger, there would seem to be no centrosomes present, judging from the researches of Mitzkewitch, who figures the spindle as drawn to a point at the pole without a centrosome. Strasburger concludes that the lens-shaped thickenings on the plasma membrane from which the cilia develop in the case of *Vaucheria*, *Œdogonium*, etc., are to be considered the homologues of the blepharoplasts in *Zamia*, etc. He says:

> This organ we will at once designate as a blepharoplast, as I consider it homologous to the blepharoplasts of plant spermatogonia. The name was well selected; at least, I know of no reason for changing it.[1]

The development of sexually differentiated gametes is generally admitted to have taken place by development from swarmspores, and a study of plants showing early stages of sexual differentiation is thus of importance. Strasburger points out that in *Volvox*, which is such a plant, the cilia originate in a *Mundstelle* similar to that of *Œdogonium*, which he considers to be a blepharoplast. This derivation of the blepharoplasts of the *Cycadaceæ* from similar organs existing in lower plants is of the highest importance and indicates a general similarity in the mode of forming cilia in all motile reproductive cells.

Many important points yet remain to be determined in regard to the blepharoplasts before the controversy regarding their nature can be finally settled. No final conclusion can be reached, furthermore, until our knowledge of the typical centrosome has been extended and systematized so that it is possible to state what constitutes a centrosome. If the writer by his efforts has in any degree aided in paving the way to an earlier understanding of the matter, he is satisfied.

SUMMARY.

(1) The researches have shown that there are at least two species of *Zamia* in Florida, where only one has heretofore been recognized as occurring. These are *Zamia floridana* DC. and *Z. pumila* L. It was found that neither of the forms studied could be referred to *Z. integrifolia* Jacq., as has been done heretofore, this being a very distinct West Indian species.

(2) *Zamia* cones in various stages of development can be shipped by mail or express at least a three to five days' journey, and arrive in perfectly satisfactory condition for microscopic embryological study. Material preserved in the cone for six to ten days, as this requires, has been carefully compared with freshly cut material and found to

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[1] Dieses Organ wollen wir gleich als Blepharoplasten bezeichnen da ich es für homolog den Blepharoplasten der pflanzlichen Spermatogonien halte. Der Name kann als gut gewählt gelten, zum Mindsten sehe ich keine Veranlassung ihn zu ändern.

have undergone no perceptible change. Zamia material in good condition for demonstration and for careful study of the details of spermatogenesis and fecundation can thus easily be obtained by any of the universities in Eastern United States. The comparative dates of development of different stages is given in the paper.

(3) Pollination is accomplished by the wind. The scales of the cone gradually reflex from the base upward in regular sequence, leaving an opening about one-fourth of an inch wide between the scales when fully open, into which the pollen must be blown to cause fecundation. When blown into the cone in this way it naturally rattles down to the axis of the cone near the micropyle of the ovary. In the further process of pollination a mucilaginous fluid is evidently extruded, which catches the pollen grains and is later drawn into the pollen chamber at the apex of the nucellus, either by absorption or by suction created by the breaking down of the tissue in the formation of the pollen chamber. In this way the pollen grains come to lie in the pollen chamber at the apex of the nucellus, where they germinate and form the spermatozoids.

(4) The mature pollen grain has two small prothallial cells cut off on one side of the grain, which are developed while the grain is still in the pollen sac. Indications of a resorbed prothallial cell have been observed in mature pollen grains and in grains shortly after germination. While the development of the pollen grain has not been followed, and the matter is somewhat doubtful, yet it is believed that three prothallial cells are cut off occasionally, if not regularly, the first of which is uniformly resorbed, as in the case of *Ginkgo* and *Pinus*. The two cells which remain plainly evident in the pollen-grain cells are referred to as the first and second prothallial cells, in the order of their formation.

(5) In the development of a stalk cell and central cell (generative cell or *Körper* cell) *Zamia* is found to correspond very closely to the Coniferæ as described by Strasburger and Belajeff. The general process is obscured, however, by the early development of the prothallial cells before the division of the second prothallial cell occurs. The first prothallial cell early begins to arch out into the second prothallial cell. As the development progresses this continues till the second prothallial cell comes to surround the main body of the first prothallial cell. The division of the second prothallial cell occurs after this condition is formed and the lower end of the spindle is crowded to one side by the intruding first prothallial cell. When the wall separating the stalk cell and the central cell is formed it is located near the apex of the first prothallial cell, so that the puzzling appearance of a cell surrounding a cell is formed. The nucleus of the stalk cell is always crowded to one side by the first prothallial cell. The writer has found the same process of development to occur in *Ginkgo* also.

(6) Shortly after the completion of this division the blepharoplasts

arise in the central cell, being formed *de novo* in the cytoplasm either in close proximity to the nuclear membrane or midway between the nuclear membrane and cell wall. They are at first very small, being scarcely more than points where a few radiating filaments converge. No distinct granules or differentiated central organ can be detected at this time.

(7) The blepharoplasts gradually increase in size, an outside surrounding membrane and vacuolated contents of different structure and composition being soon differentiated. They continue to grow until they reach a size, shortly before division, of about 18 to 20 μ in diameter. The kinoplasmic filaments, of which there were at first very few, increase in number until they become very numerous. The entire central cell and nucleus, together with the stalk cell and nucleus also, grow very materially in size.

(8) The prophase of division of the central cell appears to be the same as in ordinary cells. In this stage the blepharoplast has reached its largest size and has frequently become elliptical. Its contents present a beautiful, regularly vacuolate structure, and stain red with safranin.

(9) A synapsis stage is formed in the division of the central cell similar to the synapsis stage in the division of the pollen mother cells of various plants. This condition is not due to contraction, as the entire nucleus is filled with an unstained ground plasm which exhibits a reticular structure and shows no indication of contraction. In the collection of the chromatin matter around the nucleolus the chromatin granules apparently move along the meshes of this reticulum.

(10) As the division approaches the equatorial-plate stage the blepharoplasts begin to break up, the contents contracting and gradually disappearing, while the outer membrane begins to break apart here and there and can be observed to be made up of very numerous granules. The kinoplasmic filaments surrounding the blepharoplast, which in the previous stage had been very abundant, seem to have disappeared or at least are unrecognizable from the surrounding reticulum.

(11) The spindle is developed while the nuclear membrane is intact throughout, being apparently entirely of nuclear origin. In the equatorial-plate stage none of the spindle fibers can be traced beyond the nuclear membrane, and certainly have no connection with the blepharoplast.

(12) In an early anaphase the stainable contents of the blepharoplast have entirely disappeared, its place being taken by a colorless ground plasm. The outer membrane is more segmented and the individual granules of the membrane are clearly distinguishable. The nuclear membrane has broken down and its place is occupied by spindle fibers, which preserve the original shape of the nucleus. The spindle is fully formed now and the poles push very slightly out of the original nuclear limitations. There is no system of radiations surrounding the

pole of the spindle. In well-stained sections the spindle fibers can be seen to end abruptly in a loose reticular cytoplasm, a specialized area of which surrounds the pole of the spindle in the locations where the daughter nuclei are to be organized. The radiations surrounding the blepharoplast still exist in this stage, but are by no means so plain and abundant as in earlier stages. They have no connection with the spindle fibers, and end in the cytoplasm before they reach the specialized area of cytoplasm surrounding the spindle pole.

(13) In no stage have the kinoplasmic radiations of the blepharoplast been observed to grow in and take part in spindle formation, or in any way have any connection with the spindle other than that they lie in the line of symmetry of the cell, being naturally just outside the poles of the spindle.

(14) As development progresses the blepharoplasts break up entirely into numerous granules, the granules being apparently the same as those visible in the structure of the membrane of the blepharoplast in the last stage. By the time the blepharoplast has reached this stage the daughter nuclei have been fairly well organized.

(15) During the formation of the cell plate by the contraction and metamorphosis of the spindle fibers the process of organizing the cilia-bearing band from the blepharoplast is in progress. At first a slight line can be observed protruding slightly from the mass of granules of the blepharoplast. This line gradually increases in length, and one grows out on the opposite side of the mass of granules in the same way. Finally this line can be observed to have a definite width, which gradually increases. Careful observation shows this band to be formed by the fusion of the granules of the blepharoplast, a fact first pointed out by the writer. As the band continues to grow in length and width the blepharoplast granules gradually disappear until finally all are used up. The daughter nuclei by this time have reached a resting condition and form the spermatid cells which later become metamorphosed into the spermatozoids.

(16) A feature brought out in the writer's studies of *Zamia* for the first time is that here the entire spermatid cell is metamorphosed into a spermatozoid, there being no differentiation of spermatozoids inside of a mother cell, as was previously understood to be the case in the spermatogenesis of plants.

(17) The band formed, as above described, continues to grow in length some time after the disappearance of the granules of the blepharoplast. At this time it has usually formed one turn around the spermatid. It is first located in the cytoplasm midway between the nucleus and periphery of the cell, but ultimately moves out and becomes appressed against the plasma membrane. It assumes the form of a helicoid spiral as it elongates and finally makes from five to six turns around the cell. In a very early stage protuberances can

be distinguished on the outer surface of the band which ultimately grow into cilia.

(18) While the growth and division of the central cell has been taking place tissue changes have occurred in the upper part of the nucellus and the pollen-grain ends of the pollen tubes have grown down so that they hang free into the archegonial chamber over the neck cells of the archegonia. In fecundation the pollen tubes grow down until they crowd against the neck cells, and, being under severe tension, burst and discharge the spermatozoids over the archegonia. The fluid for the swimming of the spermatozoids is surely formed in part from the pollen tube and may be partially formed by extrusion from the egg cell.

(19) The mature spermatozoids are the largest known to occur in any plant or animal, being visible to the unaided eye. Their motions have been carefully studied by keeping them alive in sugar solutions. They are ovate or nearly spherical, the apex of the ciliferous spiral being usually more or less pointed. Their motion is mainly by the aid of the cilia, but besides this they have a sort of selective amœboid motion of the spiral end.

(20) In fecundation the entire spermatozoid enters the egg cell, swimming in between the ruptured neck cells. Sometimes two or three spermatozoids enter the same egg, but only one is used in fecundation, the others perishing.

(21) On entering the upper part of the egg cytoplasm the nucleus escapes from the spermatozoid, being left slightly in rear of the active ciliferous band. The plasma membrane of the spermatozoid entirely disappears, seeming to unite with the cytoplasm of the egg, and this allows the spermatozoid cytoplasm also to unite with the egg cytoplasm and leaves the nucleus free. The ciliferous band remains at the apex of the egg cell in the cytoplasm and the nucleus passes on to the egg nucleus, with which it unites.

(22) Fecundation thus consists of a fusion of two entire cells—cytoplasm with cytoplasm and nucleus with nucleus.

(23) The first division of the egg nucleus has not been observed, but the second and later divisions have been carefully studied. In no case of the cleavage divisions has any centrosome been observed or other body at the pole of the spindle which might be confused with a centrosome. The development has been followed until the embryo is fairly well organized, so that it may be concluded that there is no centrosome present in the divisions closely following the first cleavage of the egg nucleus. It is certain that the ciliferous band, which represents the blepharoplast of the spermatid, has no function in the formation of the first cleavage spindle or the spindles in any of the divisions immediately following, as it remains intact at the apex of the egg cell until the egg nucleus has divided into very many small nuclei.

It disappears later, during the formation of the embryo, being apparently absorbed during the process.

(24) The function of the blepharoplast from the results obtained in this study appears to be simply the formation of the motile cilia and the transportation of the male cell. It forms the machinery of locomotion.

(25) The greatest interest in the present paper is in the relation of the blepharoplast to centrosomes or centrospheres. They are found to differ from centrosomes as generally understood (1) in not forming the center of an aster at the pole of the spindle, being located entirely outside of the spindle in *Zamia*, *Ginkgo*, and *Cycas;* (2) in having no connection with spindle formation; (3) in being limited to the division of a single cell, thus to one cell generation, no similar organ appearing in any other stage of the plant's development, so far as known, and (4) in having a function differing from that of any typical centrosome, so far as known in plants.

(26) Considering the organs distinct from centrosomes, the writer in an earlier preliminary paper called them *blepharoplasts.* This the writer contends was justifiable and proper, even if the organs are finally proven to be the homologues of centrosomes. They are now very certainly specialized organs functioning only as cilia formers.

WASHINGTON, D. C., *May 1, 1901.*

NOTE.—Since this monograph went to press several important papers bearing directly on the subject have appeared, but as these do not serve to change the writer's conclusions or materially affect the discussion, no special consideration of them is here necessary. The most important of these is Dr. S. Ikeno's paper entitled "Contribution a l'étude de la fécondation chez le Ginkgo biloba," published in 1891 (Ann. d. Sci. Nat. Bot. VII, sr. **13**: 305–318).

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EXPLANATION OF ILLUSTRATIONS.

All of the figures were drawn with the aid of a camera lucida, and where high magnification was used, with Zeiss apochromatic objectives 3 mm., n. a. 1.40, or 2 mm., n. a. 1.30.

PLATE I.

Zamia floridana.

Fig. 1. Median longitudinal section through upper part of ovule at time of pollination: *c*, coat of ovule; *m*, micropyle; *pc*, pollen chamber; *n*, nucellus; *p*, prothallus. (× 18 diam.)

Fig. 2. Median cross section of female cone at time of pollination. (½ nat. size.)

Fig. 3. Mature pollen cone with pollen shedding. (½ nat. size.)

Fig. 4. Cross section of mature pollen cone, showing pollen sacks on lower surface of scales. (½ nat. size.)

Fig. 5. Median longitudinal section through apex of nucellus, showing pollen chamber and developing pollen tubes. (× 100 diam.)

Fig. 6. Cone at time of fecundation, having reached maximum size. (½ nat. size.)

Fig. 7. Scale and attached seeds at time of fecundation. (½ nat. size.)

Fig. 8. Two seeds at time of fecundation, having reached maximum size. (½ nat. size.)

Fig. 9. Median section through seed just before fecundation, showing relative size and location of parts (diagrammatic); *c*, coat of ovule; *m*, micropyle; *n*, nucellus, showing pollen tubes hanging down into the archegonal chamber *ac;* *e*, egg cell; *p*, prothallus. (× 3 diam.)

Fig. 10. Median section through young archegonium, showing central cell and nucleus before the cutting off of the canal cell. (× 100 diam.)

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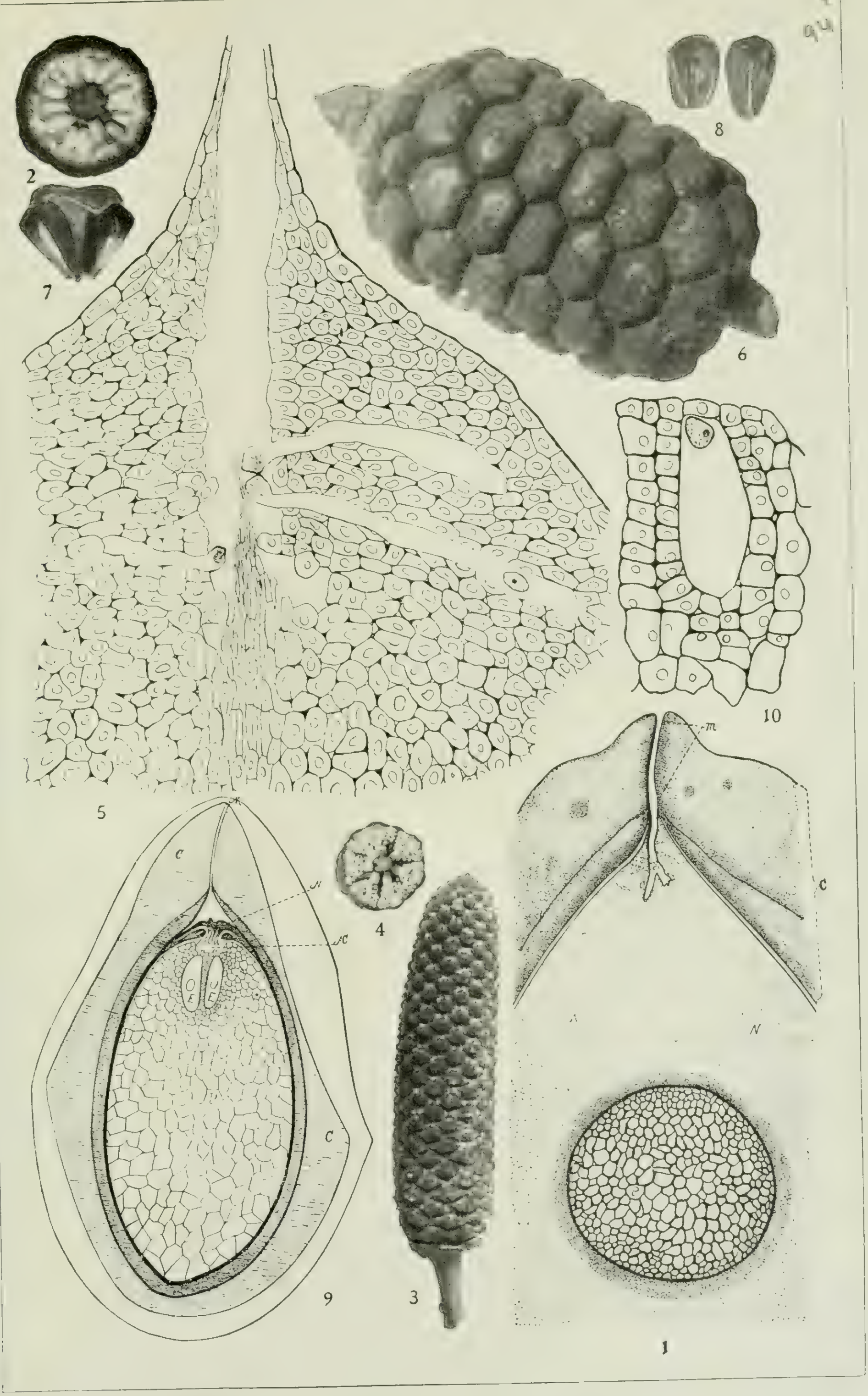
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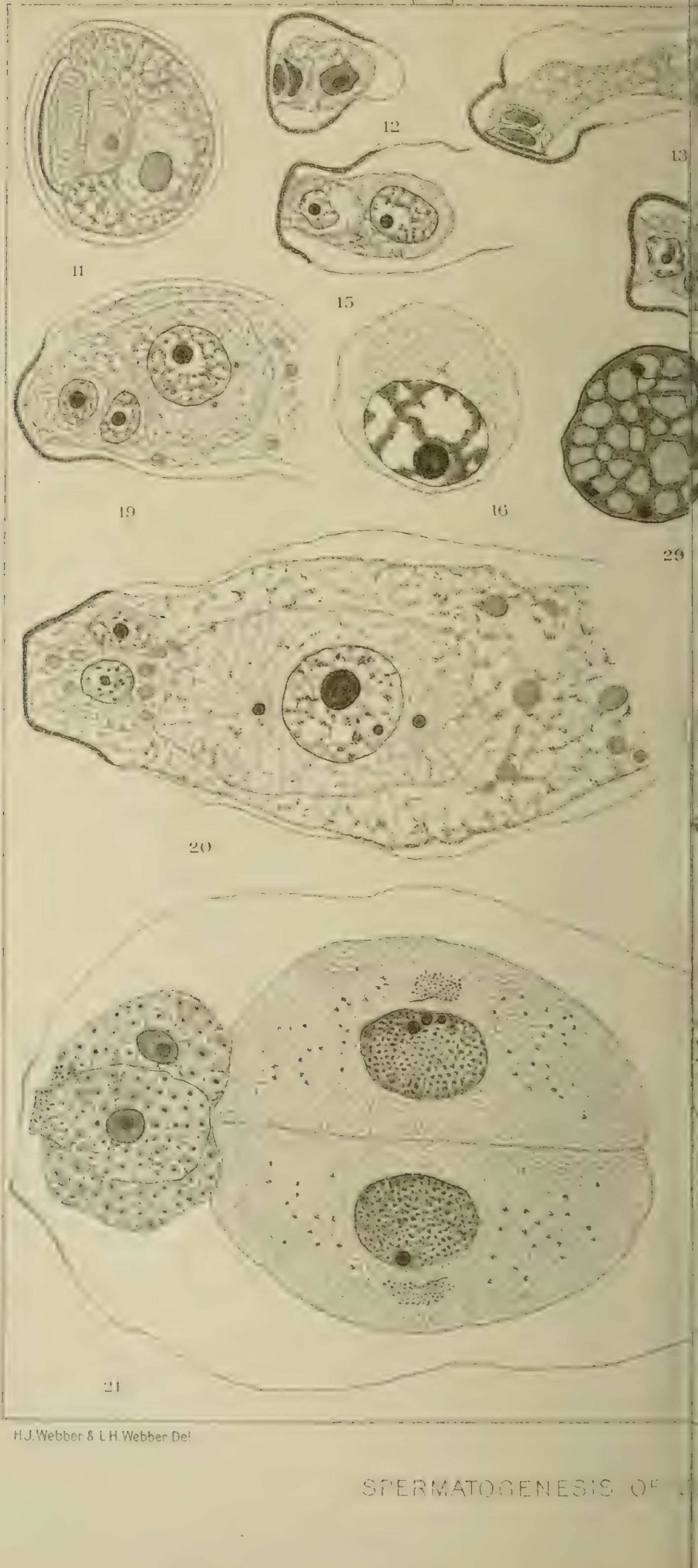
SPERMATOGENESIS OF ZAMIA FLORIDANA.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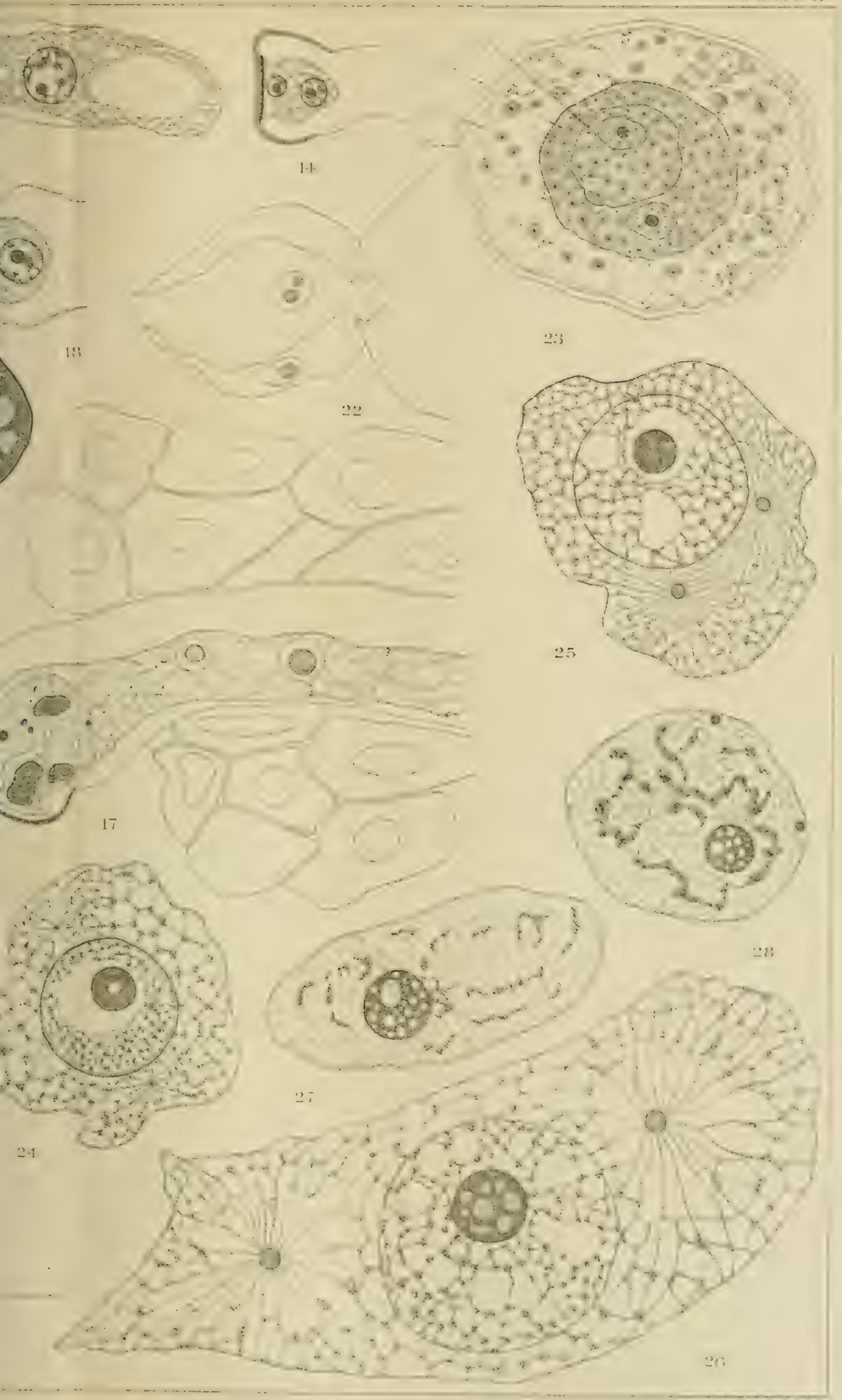
SPERMATOGENESIS OF

PLATE II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IA FLORIDANA AND ZAMIA PUMILA

PLATE II.

Zamia floridana and *Zamia pumila.*

Fig. 11. Mature pollen grain in water. At the point of attachment of the two prothallial cells, on the left, a dark crescent-shaped line represents a dark layer in the cell wall of pollen grain, which may be the remains of a third resorbed prothallial cell. (× 1,200 diam.)

Fig. 12. Germinating pollen grain, early stage. The two prothallial cells have not yet begun to increase in size. (× 600 diam.)

Fig. 13. Germinating pollen grain, later stage. The tube nucleus has increased in size and has passed out of the old grain into the tube, the prothallial cells still remain unchanged. A dark line at base of attachment of prothallus in this tube may be the remains of a third prothallial cell. (× 600 diam.)

Fig. 14. Germinating pollen grain, later stage. Here the first prothallial cell has just started to push out into the second prothallial cell. (× 600 diam.)

Fig. 15. Germinating pollen grain, later stage. The first prothallial cell has crowded out into the second prothallial cell in a marked degree. (× 600 diam.)

Fig. 16. Transverse section of second prothallial cell in early prophase of division, showing one of the bodies which may occasionally be found, that resemble the early stages of a blepharoplast. (× 1,200 diam.)

Fig. 17. Pollen tube penetrating nucellar tissue, and showing the nucleus of the second prothallial cell in division, the lower end of the spindle being crowded to one side by the intruding first prothallial cell. (× 600 diam.)

Fig. 18. Prothallus of pollen tube immediately after the completion of the division of the second prothallial cell into a stalk cell and central cell. Two starch grains are shown here in the second prothallial cell. (× 600 diam.)

Fig. 19. Prothallus of pollen tube in a later stage of development after the appearance of the blepharoplasts. The double plasma membrane separating the first prothallial cell and stalk cell, which is here visible, shows that there are two distinct and independent cells of separate origin. (× 600 diam.)

Fig. 20. Prothallus of pollen tube in a later stage of development after central cell has become elongated and the blepharoplasts have taken position on opposite sides of the nucleus, corresponding to the longitudinal axis of the pollen tube. Starch grains have begun to appear in the stalk cell, etc. (× 600 diam.)

Fig. 21. Prothallus of pollen tube very much later after the division of the central cell; the blepharoplasts have separated into granules which are starting to organize the ciliferous band. The first prothallial cell and stalk cell have become gorged with starch. The original size of the attachment of the first prothallial cell is clearly shown at base of that cell. (× 300 diam.) This tube is magnified only one-half as much as that shown in fig. 20.

Fig. 22. Prothallus showing the interior first prothallial cell crowding into the central cell. (× 300 diam.)

Fig. 23. Cross section of pollen tube extending through stalk cell and interior first prothallial cell: *w*, wall of pollen tube; *cp*, cytoplasm of pollen tube; *sc*, stalk cell; P1, first prothallial cell. (× 300 diam.)

Fig. 24. Central cell with blepharoplasts shortly after origin. (× 1,200 diam.)

Fig. 25. Central cell with blepharoplasts near together and somewhat older, when outer membrane has been differentiated. (× 1,200 diam.)

Fig. 26. Central cell with blepharoplasts in median stage of development, showing relation of kinoplasmic radiations to reticulum of cytoplasm. (× 1,200 diam.)

Fig. 27. Nucleus of central cell in early prophase of division, the chromatin matter beginning to collect in granular masses. (× 350 diam.)

Fig. 28. Nucleus of central cell in later prophase of division, the chromatin having collected in a skein. (× 350 diam.)

Fig. 29. Blepharoplasts, showing vacuolated contents and refractive bodies resembling crystalloids. (× 1,200 diam.)

PLATE III.

Zamia floridana and *Zamia pumila.*

Fig. 30. Division of central cell, synapsis stage, showing the collection of the chromatin matter around the nucleolus, and reticular ground plasm filling the remaining portion of the nucleus. (× 350 diam.)

Fig. 31. Division of central cell, equatorial plate stage, showing the blunt-poled intranuclear spindle, the outer membrane of the blepharoplasts breaking up, and the contracting of the contents of the blepharoplast. (× 350 diam.)

Fig. 32. One of the blepharoplasts from the above cell more highly magnified, showing the breaking up of the exterior membrane and the disappearance of the contents. (× 1,200 diam.)

Fig. 33. Division of central cell, early anaphase, showing hyaline cytoplasmic areas around the poles and disconnection of the blepharoplasts with the spindle. (× 350 diam.)

Fig. 34. One of the blepharoplasts and the pole of the spindle from the above cell more highly magnified, to show the relation of the kinoplasmic rays surrounding the blepharoplasts to the spindle fibers, the granular structure of the outer membrane of the blepharoplast, and its separation and contents at this time. (× 1,200 diam.)

Fig. 35. Division of central cell, early telophase, showing the reorganization of the daughter nuclei. The blepharoplasts have separated into groups of granules, which, in this stage, are nearly as large as the daughter nuclei. (× 350 diam.) (Compare this with a photomicrograph of the same cell, Pl. V, fig. 63.)

Fig. 36. Two attached spermatids formed by the completion of the division of the central cell. The blepharoplast is in the process of organizing the ciliferous band by the fusion of the granules. (× 350 diam.)

Fig. 37. Organization of the ciliferous band by a fusion of the granules of the blepharoplast. (× 1,200 diam.)

Fig. 38. Fusion of the granules of the blepharoplast in the formation of the ciliferous band. (× 1,200 diam.)

Fig. 39. Spermatid showing irregular projections from the nucleus, and with ciliferous band in process of construction. (× 350 diam.)

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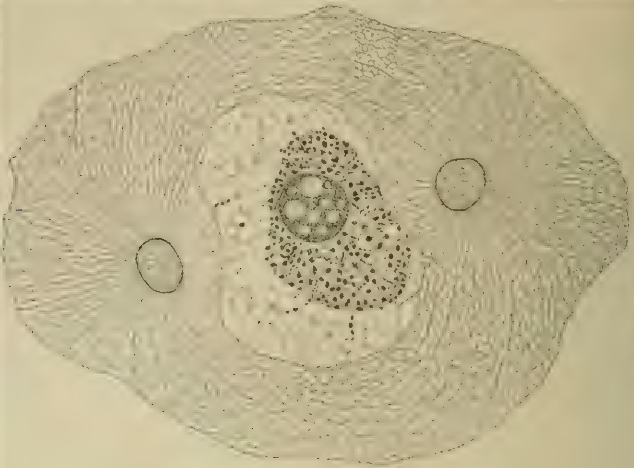

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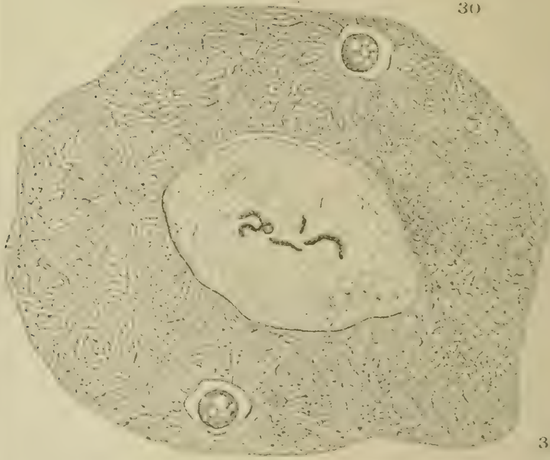

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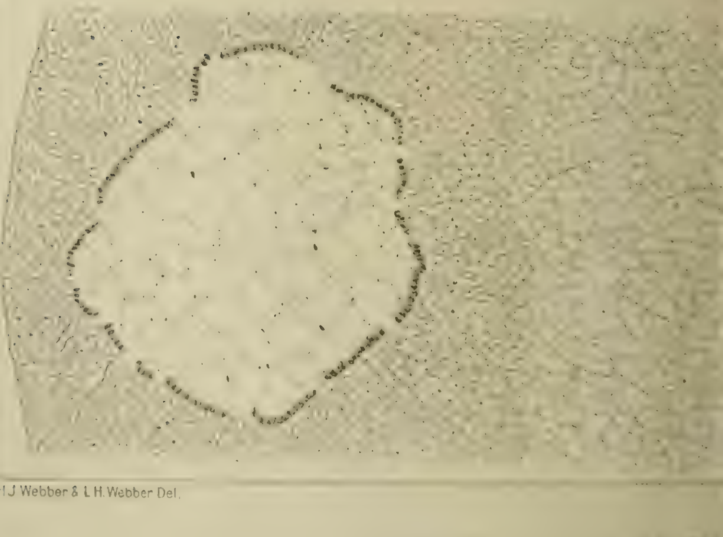

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SPERMATOGENESIS OF ZA

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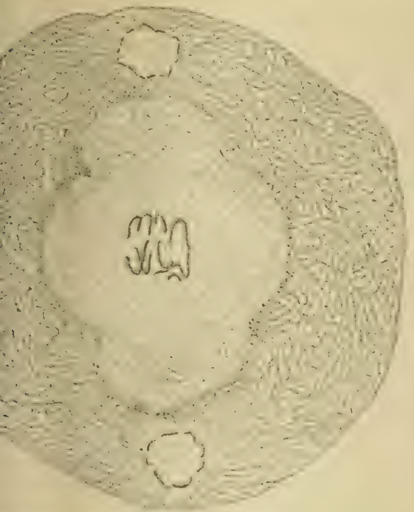

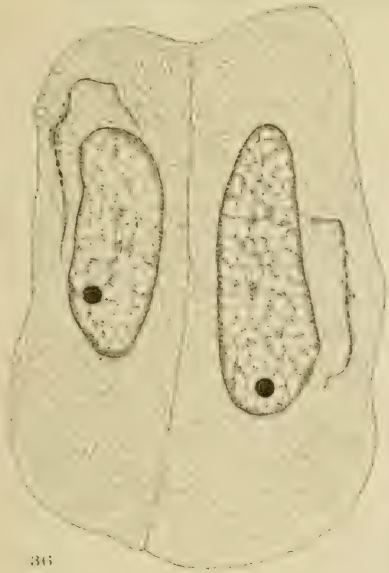

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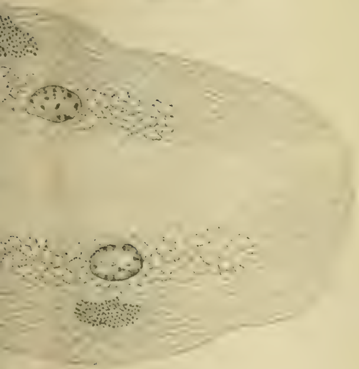

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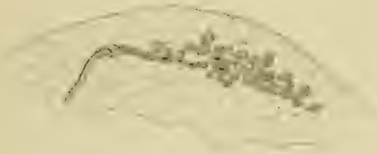

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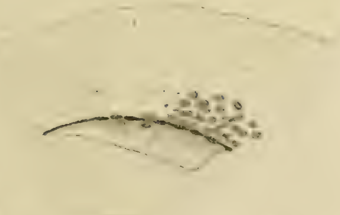

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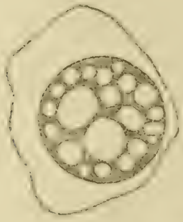

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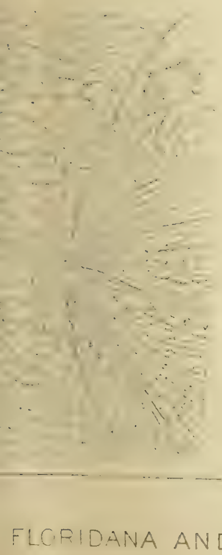

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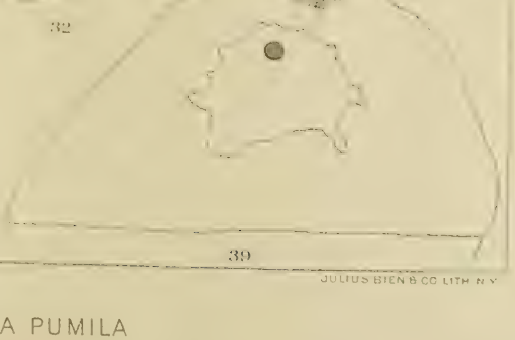

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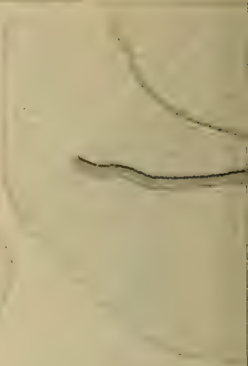
FLORIDANA AND ZAMIA PUMILA



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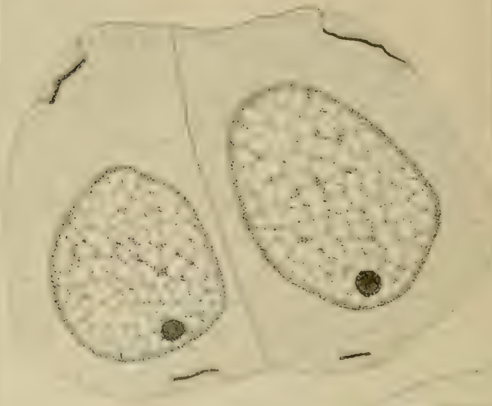

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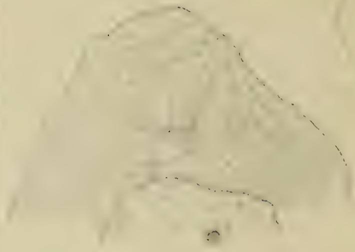

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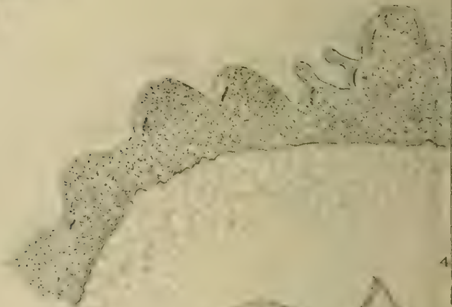

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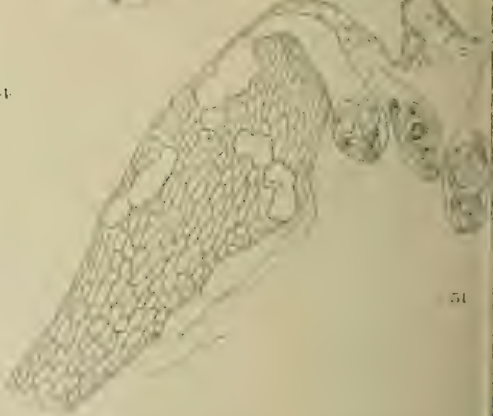

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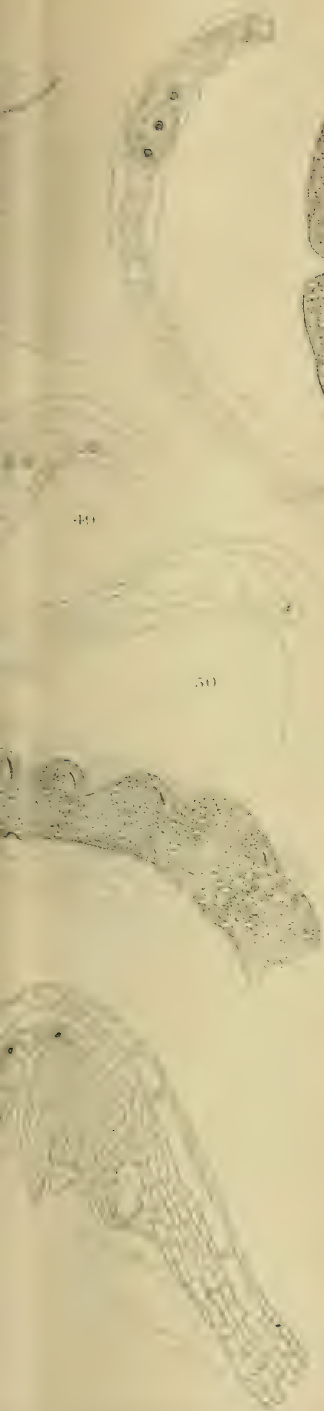
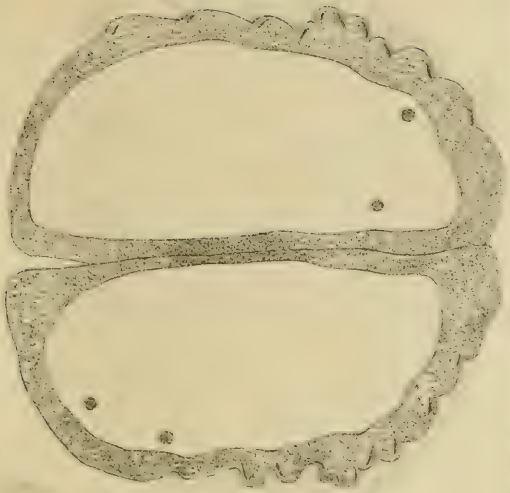
SPERMATOGENESIS OF ZAMI

PLATE IV





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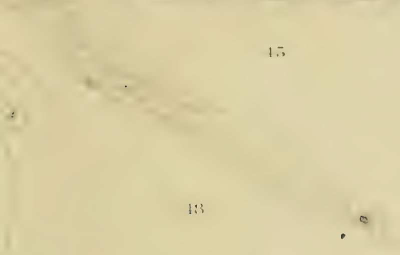

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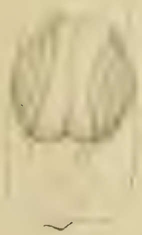

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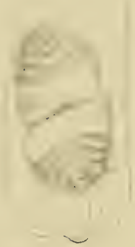

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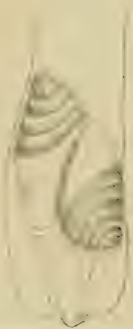

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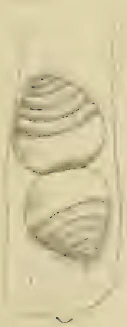

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FLORIDANA AND ZAMIA PUMILA

PLATE IV.

Zamia floridana and *Zamia pumila.*

Fig. 40. Spermatid with section of ciliferous band in cytoplasm, showing protuberances on outer side. (× 600 diam.)

Fig. 41. Spermatid with section of ciliferous band in cytoplasm, showing radiations from outer surface. (× 350 diam.)

Fig. 42. Median section of two spermatids where ciliferous band has made a single turn around the cell, showing band in section appressed against the plasma membrane on opposite sides of the nucleus. (× 350 diam.)

Fig. 43. Tangential surface section of a spermatid, showing surface of band when it had made a single turn. (× 350 diam.)

Fig. 44. Formation of double plasma membrane in the division of the central cell. (× 1,800 diam.)

Fig. 45. Mature spermatozoids in median section, showing nuclei, ciliferous band, etc. (× 200 diam.)

Fig. 46. Cross-section of apex of spermatozoid, showing attachment of cilia to band which lies immediately below the plasma membrane. (× 600 diam.)

Fig. 47. Separation of spermatozoids under the influence of sugar solution: *a*, mature pollen tube just before motion began; *b*, *c*, and *d*, after the motion of the cilia had begun, showing stages in the gradual pulling apart of the spermatozoids.

Fig. 48. Pollen tube in a median stage of growth, showing the tube nucleus near the distal end of the tube. (× 75 diam.)

Figs. 49 and 50. Pollen tubes, showing different shapes assumed by the tubes in the course of the growth of the proximal end, just preceding fecundation. (× 75 diam.)

Fig. 51. Apex of nucellus, showing the proximal ends of the pollen tubes hanging down in the archegonial chamber shortly before fecundation. The tube nuclei have returned and taken position near the prothallus. (× 75 diam.)

PLATE V.

Zamia floridana and *Zamia pumila*.

Fig. 52. Mature spermatozoid while swimming free. (× 200 diam.)

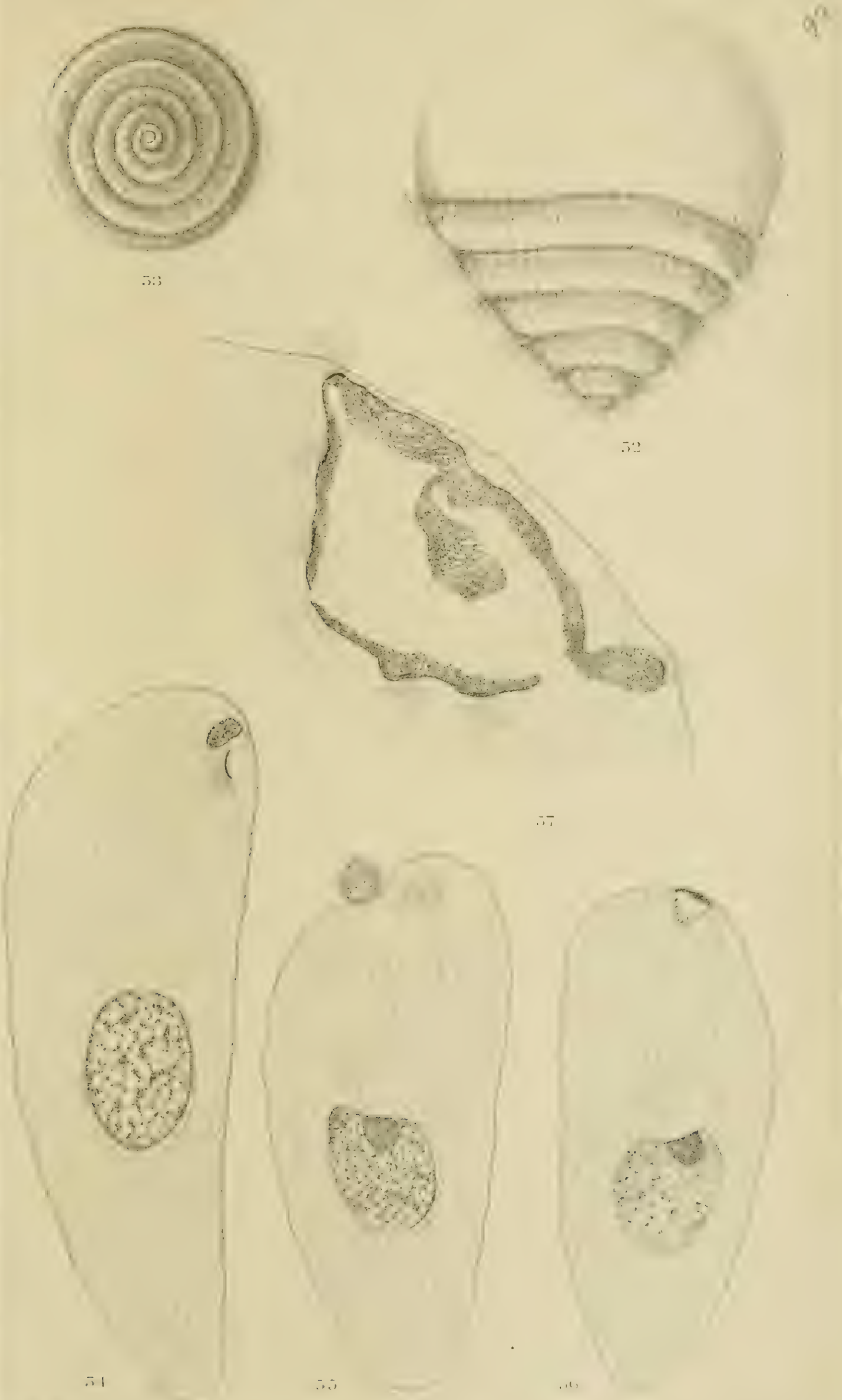
Fig. 53. Spermatozoid showing apex of spiral.

Fig. 54. Fecundated egg cell immediately before nuclear fusion, the nucleus of the spermatozoid having separated from the ciliferous band and cytoplasm, lies free in the protoplasm at the apex of the egg cell ready to travel on alone and fuse with the egg nucleus. (× 25 diam.)

Fig. 55. Egg cell immediately after the fusion of the male and female nuclei, showing male nucleus in the upper portion of the oosphere, and the isolated ciliferous band of the spermatozoid which produced the fecundation lying free in the cytoplasm at the apex of the egg cell. A second spermatozoid trying to gain entrance is shown at apex of cell. (× 25 diam.)

Fig. 56. Egg cell immediately after fusion of male and female nuclei as in fig. 55, showing longitudinal section of ciliferous spiral band and a portion of the cytoplasm of the spermatozoid. (× 25 diam.)

Fig. 57. Section through the apex of a fecundated egg cell showing the remains of the cytoplasm and ciliferous band of the spermatozoid surrounded by the cytoplasm of the egg cell. (× 350 diam.)



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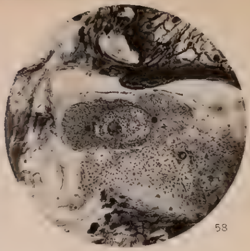
SPERMATOGENESIS AND FECUNDATION OF ZAMIA FLORIDANA AND ZAMIA PUMILA



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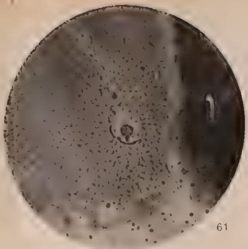

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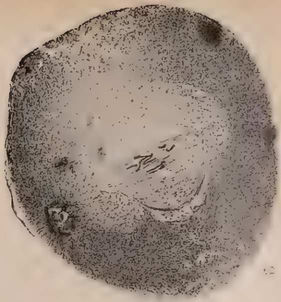

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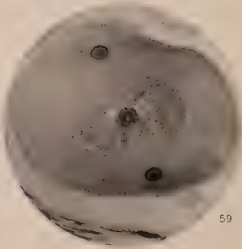

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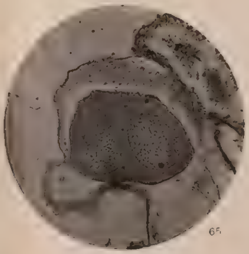

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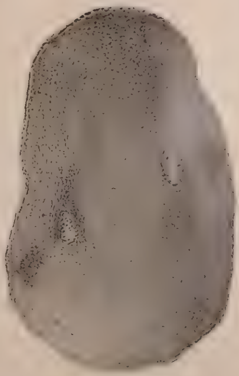

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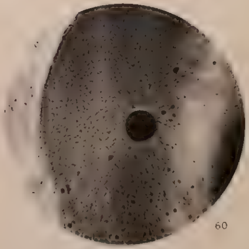

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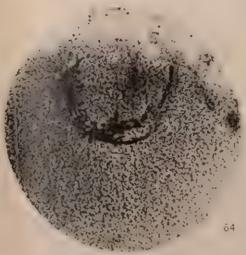

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SPERMATOGENESIS OF ZAMIA FLORIDANA AND ZAMIA PUMILA.

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PLATE VI.

Zamia floridana and *Zamia pumila*. Photomicrographs of various stages.

Fig. 58. Central cell in pollen tube showing blepharoplasts, nucleus, nucleolus, and tube nucleus below to the left. (× 200 diam.)

Fig. 59. Central cell in early prophase of division, showing blepharoplasts, contraction of nuclear membrane between blepharoplasts, nucleolus, and granular collections of chromatin matter. (× 300 diam.)

Fig. 60. Polar view of mature blepharoplast, showing radiations. (x 400 diam.)

Fig. 61. Blepharoplast, showing contraction of contents and breaking of outer membrane into segments. (× 400 diam.)

Fig. 62. Central cell in early anaphase of division, showing the relation of the blepharoplast (one only being visible) to the spindle. The clear, specialized cytoplasmic areas between the blepharoplast and the poles of the spindle are well shown. (× 400 diam.)

Fig. 63. Central cell in telophase of division, showing the blepharoplast in granules, the small daughter nuclei, and the formation of the cell plate by the contraction of the spindle fibers. (× 500 diam.)

Fig. 64. Polar view of the blepharoplast in slightly later stage, showing the fusion of the granules to form the ciliferous band. (× 400 diam.)

Fig. 65. Two spermatids where the ciliferous band has made one turn around the cell. (× 200 diam.)

PLATE VII.

Photomicrographs of *Zamia floridana.*

Fig. 66. Central cell in late telophase with the blepharoplast in granules and the delimiting plasma membrane well formed. (× 550 diam.)

Fig. 67. Mature spermatozoids in median section, showing nucleus, etc. (× 150 diam.)

Fig. 68. Mature spermatozoid swimming free in pollen tube. (× 200 diam.)

Fig. 69. Median section of helicoid ciliferous band in cytoplasm at apex of egg cell after escape of the nucleus, showing cilia still attached. Numerous little comet-like figures of kinoplasm formed here and there in the cytoplasm of the egg cell at this time are also shown. (× 450 diam.)

Fig. 70. Egg cell after fecundation, showing a spermatozoid which did not gain entrance and an empty ciliferous band in apex of egg cell. The egg nucleus is visible in the lower part of the section, but the male nucleus which has fused with it was not visible. (× 50 diam.)

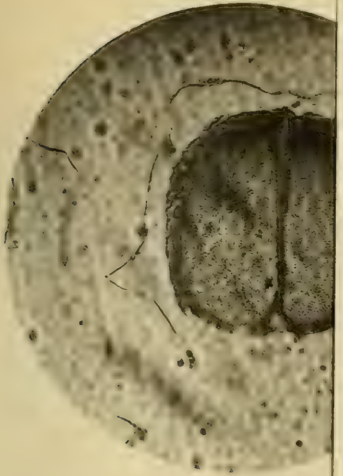

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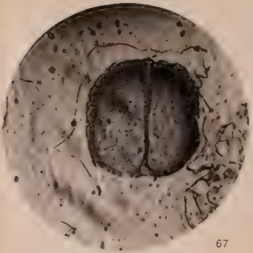
PLATE VII.



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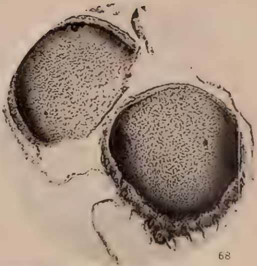

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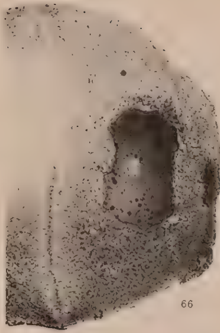

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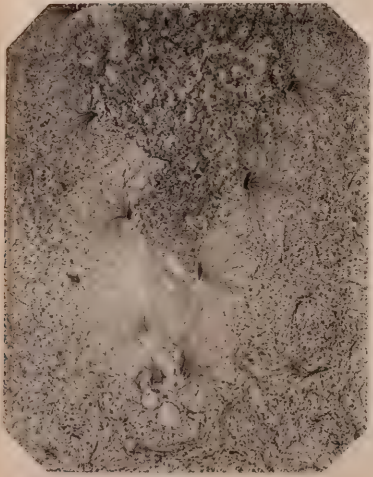

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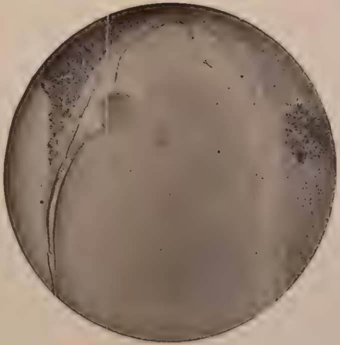

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SPERMATOGENESIS AND FECUNDATION OF ZAMIA FLORIDANA AND ZAMIA PUMILA.

HELIOTYPE CO., BOSTON

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN No. 3.

B. T. GALLOWAY, Chief of Bureau.

MACARONI WHEATS.

BY

MARK ALFRED CARLETON,

CEREALIST, VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

Issued December 23, 1901.

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1901.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 31, 1901.

Sir: I have the honor to transmit herewith the manuscript of a paper on Macaroni Wheats, by Mark Alfred Carleton, Cerealist, Vegetable Pathological and Physiological Investigations, this Bureau, and recommend its publication as Bulletin No. 3 of the Bureau series.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The following bulletin by M. A. Carleton, Cerealist of this Office, treats of the macaroni wheats, with special reference to their growth without irrigation in the semiarid regions of the United States. Some of the best varieties of macaroni wheats have been imported by the Department of Agriculture, and have been tested in these regions with extremely gratifying results. It is believed that with a little care a large industry can be built up in regions of the United States where the ordinary wheats do not succeed. Mr. Carleton has had special advantages for the study of these wheats in Russia and elsewhere, and his bulletin is commended as the latest word on a very interesting and practical subject.

ALBERT F. WOODS.

OFFICE OF THE PATHOLOGIST AND PHYSIOLOGIST,
Washington, D. C., August 1, 1901.

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MACARONI WHEATS.

By Mark Alfred Carleton,
Cerealist.

INTRODUCTION.

For more than thirty-five years there have been occasional introductions into this country of the hardy, glassy wheats of the durum group, chiefly from Russia, but also from Algeria and Chile. In Europe they are called simply hard wheats, and correctly so, since the hardest bread wheats of the world are really soft compared with them. In this country they have not until recently been sufficiently well known to receive a special name. Now, however, through the recent introductions and publications of this Department the term macaroni wheat is becoming rapidly adopted, and its application is already pretty well understood.

Heretofore these wheats have been received with but little favor. In spite of their excellent yields and hardiness the lack of a market made their establishment a practical impossibility for the time. Our own macaroni factories were using ordinary bread wheats and the attention of foreign factories had not been called to the possibility of securing excellent durum wheat from this country. Our millers refused to receive such wheat, not being able to utilize it with their present methods of milling for bread flour only. Elevator men also refused to handle it, as it would spoil the sale of other standard wheats if mixed with them in the elevators. Also the different varieties introduced had not been tested sufficiently long to obtain a just idea of their value, and were often grown in localities to which they were entirely unadapted. Thus a combination of unfortunate circumstances gave to these wheats a reputation not at all deserved. Only two years ago a writer severely criticised the Department for introducing a consignment of Kubanka wheat, saying that the variety was already considered to be a failure in this country.

Now, however, as a result of the efforts of the Department begun two years ago to establish these durum wheats, there is being manifested a great change of opinion as to their merits, in view of their probable complete utilization in the future for the manufacture of macaroni. The following are some of the reasons for this change in opinion: (1) Certain European manufacturers are ready at any time to contract for large amounts of American grown wheats of this kind so long as they stand the proper test. (2) Samples already sent to European experts for examination have given very favorable results in comparison with foreign samples, though it is almost certain that the samples sent were in quality below the average of what can be produced and is being produced in this country. (3) Quite a number of American factories are showing a disposition to use semolina[1] made from these wheats just as soon as they can obtain a sufficient amount of it. (4) Several American flour mills are now grinding macaroni wheat. (5) From a rough calculation, probably 75,000 to 100,000 bushels of macaroni wheat will be harvested in the Great Plains States in the season of 1901. (6) From the standpoint of results as a cultivated crop numerous careful experiments have absolutely proved the success of these wheats in the Great Plains. (7) Excellent bread as well as macaroni can be made and is being made in large quantities (e. g., in the Volga River region of Russia) from these wheats. In the light of such facts one is forced to believe that there is before us the possibility of establishing practically a new wheat industry of great magnitude.

CHARACTERISTICS OF MACARONI WHEATS.

Macaroni wheats proper belong in the durum group, known by the botanical name of *Triticum durum.* In France they are called *Blé dur;* in Germany, *Hartweizen;* and in Spain, *Trigo duro.* They are also sometimes called barley wheats, or *Gerstenweizen*, because of their resemblance to barley. The wheats of this group grow rather tall and have stems that are either pithy within or hollow, with an inner wall of pith, or, in a few varieties, simply hollow, as in the ordinary bread wheats. The leaves are usually broad and smooth, but have a peculiar whitish green color and possess an extremely harsh cuticle. The heads are comparatively slender in most varieties, compactly formed, occasionally very short, and are always bearded with the longest beards known among wheats. The spikelets (meshes) are two to four grained. The outer chaff is prominently and sharply keeled, and the inner chaff somewhat compressed and narrowly arched in the back. The grains are usually very hard and glassy, often translucent, yellowish-white in color, occasionally inclining to reddish, and usually rather large. In certain varieties the grains are almost or fully as large as those of Polish wheat, and are sometimes mistaken for it.

In the field these wheats resemble barley very much, and one seeing them there for the first time and not familiar with their appearance is apt to think of them as being actually barleys. There are many varieties differing in shape and size of head, color, and amount of hairiness of chaff, color of beards, etc. (See Plates I and II.) Besides their exceptional fitness for the manufacture of macaroni and other edible pastes, these wheats possess for the grower two other admirable qualities to a

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[1] The special name of the milled product as used by the macaroni manufacturer.

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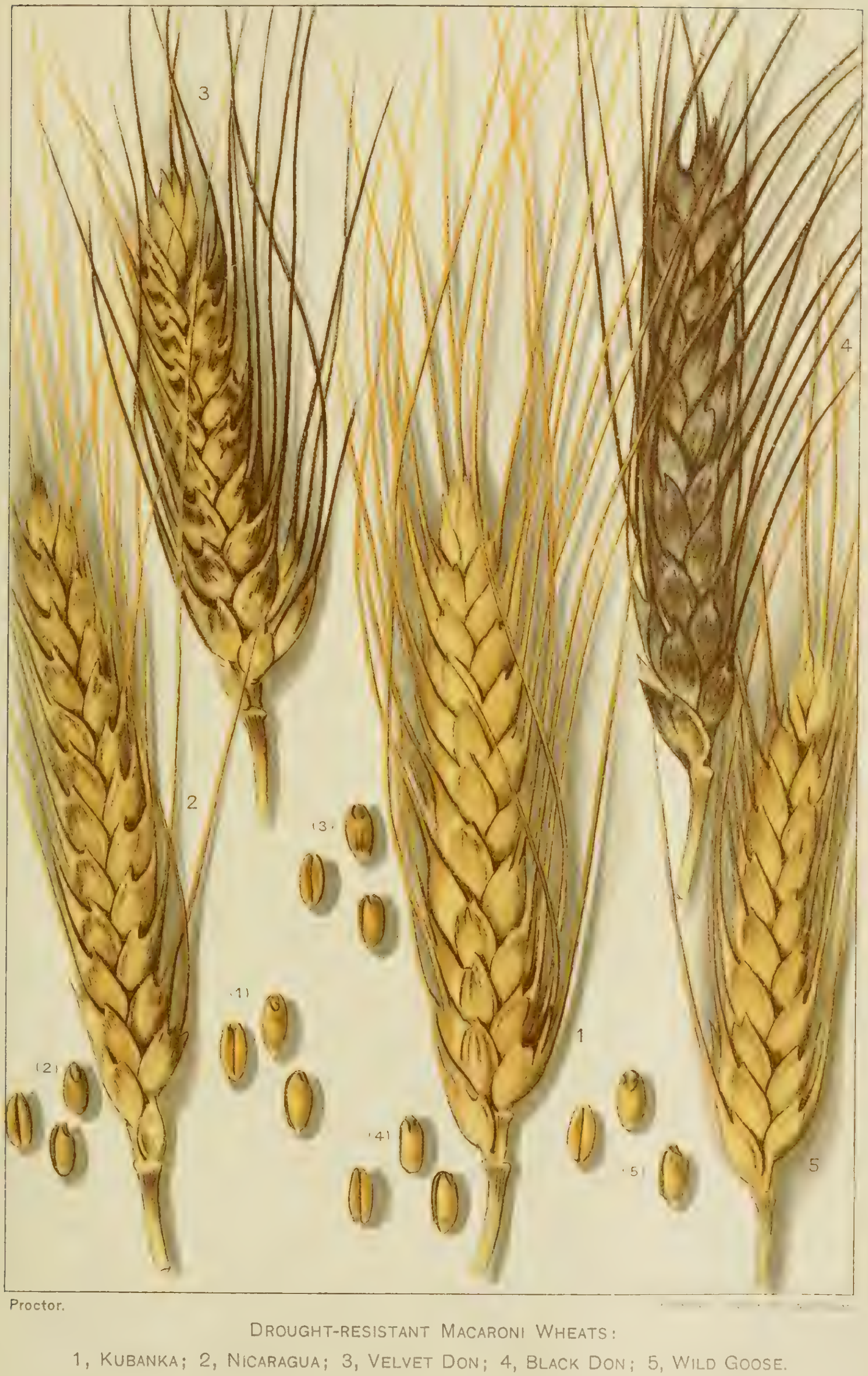

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DROUGHT-RESISTANT MACARONI WHEATS:

1, KUBANKA; 2, NICARAGUA; 3, VELVET DON; 4, BLACK DON; 5, WILD GOOSE.

greater degree than ordinary wheats. They are extremely resistant to drought and to attacks of most fungous pests. Black stem rust, however, sometimes affects them badly. They do not stool extensively. Durum wheats are particularly sensitive to changes of environment and quickly deteriorate when grown in a soil or climate to which they are not adapted. A sufficient change of conditions to effect such a result may be found even within the distance of a few miles For example, it is well understood in south Russia that the excellent variety Arnautka gives the best results only when grown within a limited area bordering the Azov Sea. So also the best Kubanka is found east of the Volga on the Siberian border. In the Caucasus this variety apparently has actually developed into a red winter wheat, though the original is a yellowish-white spring wheat.

Macaroni wheats are adapted to soils rich in nitrogenous matter but considerably alkaline, and they invariably give the best results in a hot, dry climate. Almost all the varieties are best adapted for spring sowing. The young plants are always light green in color, and even when sown in the autumn grow at once erect and very rapidly, thus being poorly prepared to survive a severe winter. Where the winters are mild, however, as they are south of the thirty-fifth parallel in this country, they may be grown as winter wheats,[1] and in such cases the large amount of autumn growth made allows them to furnish excellent fall pasturage. Polish wheats produce a grain very similar in nature to that of the durum wheats, and are also often used for making various pastes. These are varieties of *Triticum polonicum.* (See Pl. II, *1*.) The plants are tall, with smooth stems that are more or less pithy within. They stool very sparingly. The heads are extremely large and loosely formed, and before ripening are bluish green in color. A special peculiarity of Polish wheats is the rather long, narrow outer chaff, papery in structure, and standing out slightly from the head instead of being rigid and closely applied to the spikelets, as in other wheats. The grains are of great size when normal, especially quite long, yellowish white in color, and very hard. These wheats also withstand drought and are somewhat resistant to leaf rust.

Varieties of the Poulard group of wheats (*Triticum turgidum*) are also occasionally used for macaroni, but are comparatively of minor importance in this regard. The use of common bread wheats for making macaroni will be referred to in other places.

DISTRIBUTION OF MACARONI WHEATS.

Macaroni wheats stand foremost among all wheat groups in their excellent adaptation to regions of intense heat and drought. In addition, however, they require for their most successful cultivation a soil rich in humus and containing a good proportion of potash, phosphates, and lime. Where these wheats succeed best the soil is always found to be considerably alkaline. Naturally, therefore, they are grown to the greatest extent in east and south Russia, Turkestan, North Africa, and the drier portions of Argentina, Chile, India, and Asia Minor. They are also grown in Spain, Italy, Greece, Roumania, Mexico, and the Central American States.

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[1] Results of recent experiments show that they will succeed as winter wheats even in parts of Kansas.

By far the largest production of macaroni wheats is in east and south Russia, a large part of which finds a ready market for macaroni making in the cities of southern France and Italy. Ten or more rather distinct varieties are grown in Russia. These are much mixed in shipping, and are often exported under the one name of Taganrog wheat simply because they are so commonly shipped from the port of that name. There is no special variety correctly called Taganrog, but that name is usually applied to any variety whatever of Russian durum wheat after it leaves Russia.

Unfortunately in making up statistics of wheat production no distinction is made of macaroni wheats, so that it is impossible to give accurately the distribution of these wheats in Russia. In a general way, however, the governments in which these wheats are chiefly grown are as follows: Orenburg, Samara, Turghai Territory, Uralsk Territory, Saratov, Don Territory, Astrakhan, and portions of Kuban Territory, Daghestan, Stavropol, and Taurida. In the Turghai and Uralsk Territories and Astrakhan certainly the larger proportion of the entire wheat production is of these wheats, it being practically impossible to grow ordinary wheats in certain districts because of the extremely low rainfall. The farmers are, many of them, Kirghiz, who have given up nomadic habits and have adopted a settled mode of life. The chief varieties grown are Kubanka and Beloturka. The greater part of the macaroni wheat of south Russia is grown in the region bordering the Azov Sea. Here there are several varieties grown, the principal one being Gharnovka (Pl. III). In portions of Turkestan the climate is very favorable for durum wheats, because of its great aridity. One variety especially, Sarui-bugda (Pl. IV, *3*), apparently the principal durum wheat grown in Turkestan, has attained an excellent reputation in southeast Russia. Algeria produces macaroni wheats almost exclusively. As the average annual wheat production of that country during the years 1895–1900 was 23,785,167 bushels,[1] the comparative amount of these wheats grown there is therefore rather large. There are many varieties. Some macaroni wheat is also produced in Egypt and Tunis, but a large portion of Egyptian wheat is of the Poulard group (*Triticum turgidum*). Almost all Spanish varieties are of the durum group, but the entire

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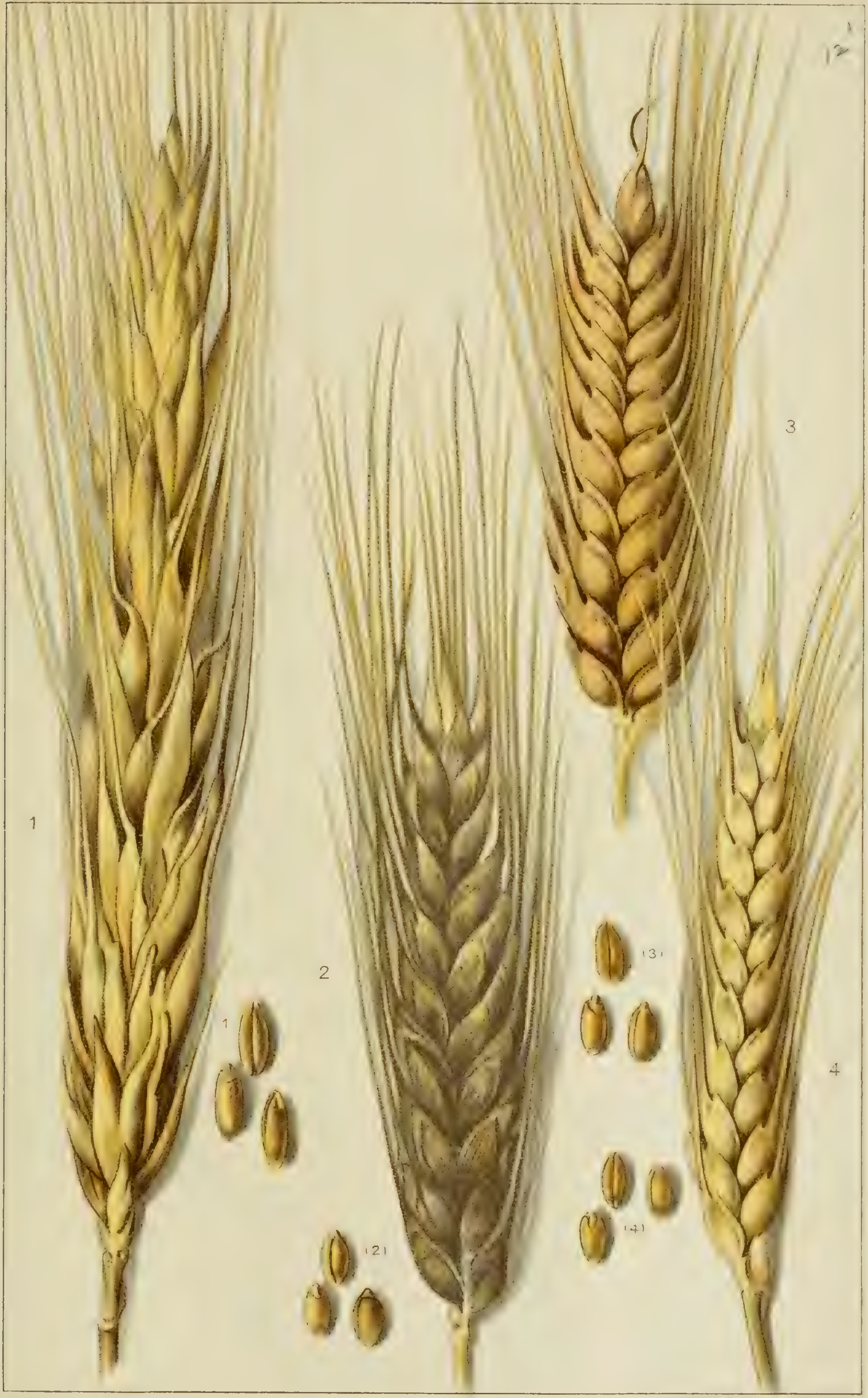
[1] Statistics furnished by the Statistician of the Department of Agriculture.



Proctor.

DROUGHT-RESISTANT MACARONI WHEATS:

1, POLISH; 2, MEDEAH; 3, MISSOGEN; 4, NO. 1174 S. P. I.

wheat production of Spain is comparatively small. In Greece, Mexico, and Central America—particularly in Nicaragua—these durum varieties are also almost exclusively grown.

ADAPTABILITY OF DURUM WHEATS TO OUR SEMIARID DISTRICTS.

The nature of the climate and soil of the regions where macaroni wheats are already grown in quantity and most successfully, would indicate that these wheats are admirably adapted to the conditions of our own semiarid districts. That this is true is pretty well proved both in theory and by experiment. Conditions of heat and drought, richness of soil, alkalinity, etc., exactly similar to those that prevail in east Russia and North Africa, exist in the more arid portions of our Great Plains, except that in the former regions these conditions are a little more extreme as a rule. As the best macaroni wheats are grown most successfully in east Russia, it will be desirable to compare the climatic conditions of that region with corresponding portions of the Great Plains, that we may note more closely the degree of similarity in this regard.

CLIMATIC COMPARISONS.

The macaroni wheat district of east Russia comprises in a general way the Volga River region from about the latitude of Kazan to the Caspian Sea, but extending eastward to the Siberian boundary and even beyond into the Kirghiz Steppes. The entire district is at least semiarid, and some portions of it seem to be, more properly, arid. The degree of aridity increases to the east and south, the reverse of the conditions in this respect in our Great Plains, where the degree of aridity increases to the west. Near the Siberian border begins the Kirghiz Steppes of western Siberia, a monotonous, unbroken expanse of treeless arid plains, with a rainfall reaching less than 10 inches, but nearly all of which falls in the growing season. Sages, feather grasses (Stipa), salt bushes, etc, make up a large part of the native vegetation. The dry heat of midsummer is so intense that mirages are frequent. The rich black earth is dry, strongly alkaline, and powdery, but absorbs greedily the rain that does fall. Evaporation goes on rapidly, and well-adapted plants are provided with means of resisting evaporation. (See Pl. V.)

The particular climatic features which characterize a region of this sort, and which distinguish it from ordinary agricultural districts so far as macaroni wheats are concerned, are as follows: (1) The very low average annual rainfall; (2) the very large proportion of this rainfall which occurs during the growing season; (3) the character of this precipitation, occurring in the form of quick thunder storms, with very little fog or mist; (4) the prevailing clearness and dryness of the atmosphere, and (5) the great extremes of temperature, especially intense summer heat.

The following table will illustrate some of these features. In this table are given the normal mean temperatures for January, July, and the year, and the normal rainfall for the year and for the growing season (May to September, inclusive) as taken at ten meteorological stations representing as fairly as possible the durum wheat districts of east and south Russia, and also similar data for nine stations corresponding to these in our Great Plains. For contrast with humid areas similar data are also given for three stations—Eastport, Oswego, and Lynchburg—in the eastern United States.

TABLE I.—*Temperature and rainfall in several localities in Russia and in the United States.*[1]

Place.	Normal mean January temperature.		Normal mean July temperature.		Normal mean yearly temperature.		Normal total rainfall, growing season.		Normal annual rainfall.	
	°*C.*	°*F.*	°*C.*	°*F.*	°*C.*	°*F.*	*Mm.*	*In.*	*Mm.*	*In.*
Kazan	−13.7	7.1	19.5	67.1	2.9	37.2	261.9	10.3	387.6	15.2
Ufa	−13.5	7.6	20.8	69.4	3.0	37.5	278.0	10.9	421.8	16.6
Simbirsk	−12.9	8.7	20.6	69.0	3.3	37.9	256.6	10.1	408.4	16.0
Samara	−12.7	9.0	21.3	70.3	4.1	39.3	251.1	9.8	396.4	15.6
Orenburg	−15.2	4.5	21.6	70.9	3.2	37.8	201.9	7.9	395.3	15.5
Orsk	....	....	....	....	....	....	146.6	5.7	270.1	10.6
Saratov	−10.1	13.7	21.7	71.0	5.4	41.7	191.9	7.5	423.1	16.6
Sarepta	−10.5	12.9	23.9	75.0	7.4	45.4	....	....	....	....
Kerch	.8	33.4	23.9	75.1	11.5	52.7	206.0	8.1	383.8	15.1
Taganrog	− 6.6	20.0	21.5	70.8	7.6	45.7	265.3	10.4	565.6	22.2
Eastport	− 6.4	20.4	15.7	60.4	5.2	41.5	451.6	17.7	1147.5	45.1
Oswego	− 4.2	24.3	20.5	69.0	8.0	46.4	375.6	14.7	889.5	35.0
Lynchburg	2.6	36.8	25.2	77.5	13.8	56.9	492.7	19.4	1094.7	43.1
Moorhead	−18.2	− .9	19.7	67.6	3.1	37.6	394.7	15.5	603.7	23.7
Bismarck	−15.2	4.5	20.8	69.5	4.2	39.6	292.1	11.5	469.9	18.5
Huron	−13.8	7.0	21.5	70.9	5.8	42.5	346.7	13.6	534.1	21.0
Yankton	− 9.8	14.2	23.1	73.6	7.6	45.8	436.8	17.2	655.3	25.8
North Platte	− 6.6	20.0	23.0	73.5	8.8	47.9	325.1	12.8	459.7	18.1
Valentine	− 8.3	16.9	22.9	73.3	7.9	46.3	299.7	11.8	486.4	19.1
Concordia	− 4.8	23.2	25.0	77.1	11.2	52.2	433.3	17.0	647.4	25.4
Dodge City	− 3.0	26.6	25.3	77.6	11.7	53.2	347.9	13.7	502.9	19.8
Abilene (Tex)	6.0	42.8	28.1	82.7	17.4	63.4	348.4	13.7	629.6	24.7

A study of the figures in the different columns for the stations in east Russia is very interesting. Great extremes of heat in one are offset by just as great extremes of cold in another. Moreover, at the northern stations the July extremes are still very high, though the yearly mean is normally very low. The small amount of *yearly* rainfall is offset by a proportionately heavy rainfall for the *growing season*. The latter will partially account for the fact that a crop can be grown at all in a district of such low annual rainfall. The contrast between

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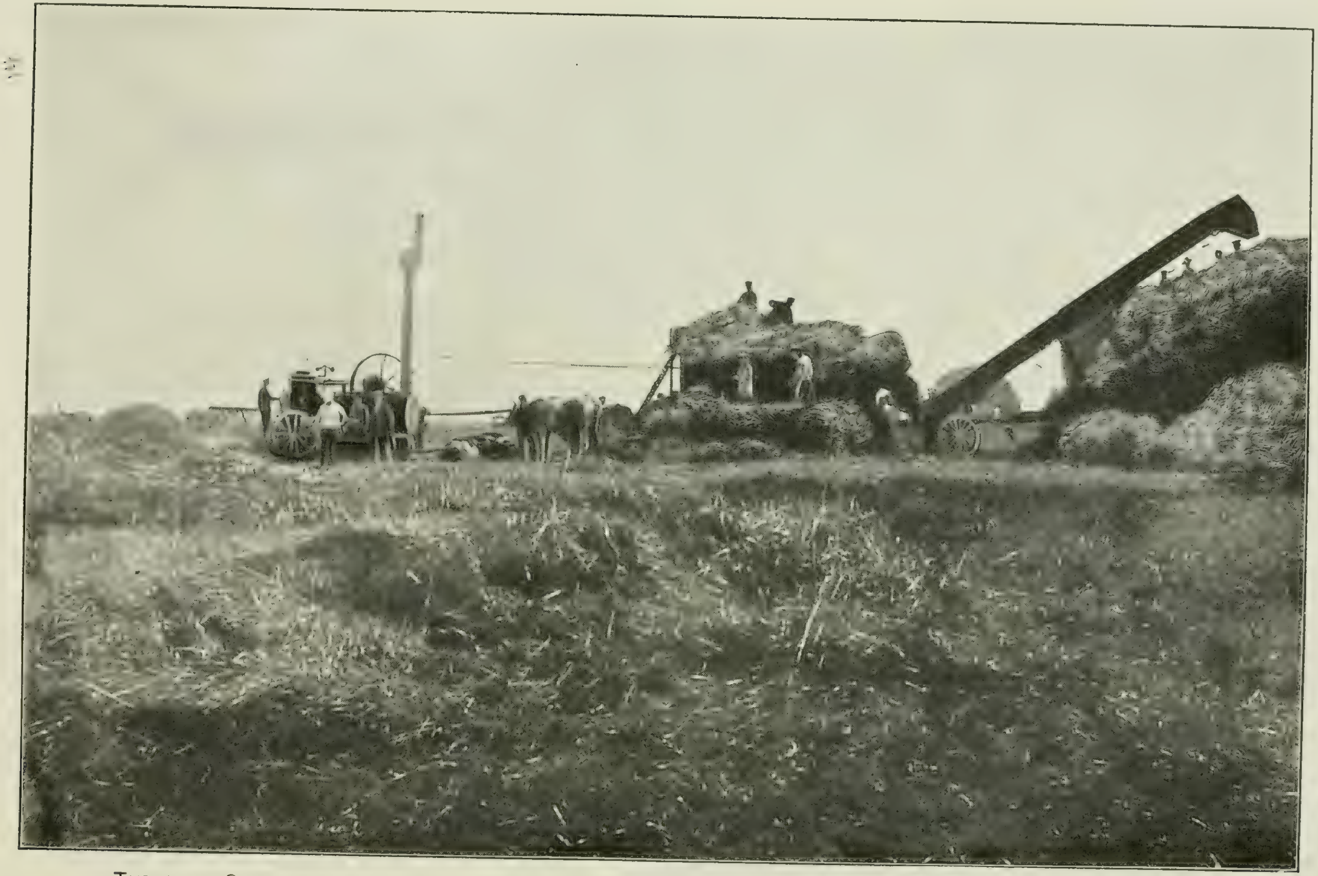
[1] The figures in this table are averages of many years' observations and are given by the following authorities: Wild, Die Temperaturverhältnisse des Russischen Reiches, Tabellen, S. LXXII–CCXL, and Die Regenverhältnisse des Russischen Reiches, S. 12–28; Kaiserl. Akad. der Wissensch. St. Petersburg, 1881 and 1887. Klossovski, Klimat Odessui (Russian); Meteorological Observatory of the Imperial New Russian University, Odessa, 1893. Moore, Report of the Chief of the Weather Bureau, U. S. Department of Agriculture, for 1896–97, Washington, D. C., 1897.



THRASHING GHARNOVKA WHEAT BY STEAM ON THE ESTATE OF MR. MIKHALKOV AT AMBROCIEVKA IN DON TERRITORY.

the figures for this district and those for the three places in the humid area of the eastern United States is very striking. While the January and mean yearly temperatures at Samara and Orenburg, Russia, are much lower than those at Oswego and Eastport, on the other hand the July temperatures at the former places are higher than those at the latter. The January and July extremes at Orenburg and Sarepta are remarkable. Orenburg, with a January normal extremely low and an annual mean normally nearly 5° lower than Oswego, yet possesses a July normal over 1½° higher. The January normal at Lynchburg is above freezing and the normal yearly mean over 6° higher than at Sarepta (see Pl. V), Russia, yet the latter point with a January normal 10½° below freezing lacks but a little over 1° of being as hot in July as Lynchburg. The anomalies of rainfall are fully as striking. At no point in the Russian region does the mean yearly rainfall reach 17 inches, while at Oswego it is over twice that amount and at Eastport and Lynchburg over two and one-half times that amount. But one-half to five-eighths of the total yearly rainfall in the Russian region occurs during the growing months (May to September, inclusive), while in the humid area of the United States considerably less than one-half falls in the growing season. The conditions at Kazan, Ufa, and Simbirsk are particularly interesting. At these points, although the yearly mean is only 16 or 17 inches, the amount falling in the growing season is about five-eighths of that amount. As the nature of the soil in prairie regions enables it to retain an unusually large proportion of the rainfall, it results that the actual amount of water available for plant growth in this semiarid area during the growing season is more than in humid areas where the yearly rainfall is two to three times as great. The lowest rainfall of this region occurs on the borders of the Kirghiz Steppes and near the Caspian Sea. At Orsk, for example, the yearly rainfall is but 10.6 inches and the mean for the growing season is 5.7 inches. But even there the actual amount of water directly available to the plants from May to September is probably nearly as large as at Oswego. In the Orsk district a considerable quantity of excellent macaroni wheat is grown.

The climatic conditions of our northern and central Great Plains region are remarkably similar to those of the region just described, except only that conditions in the former region are in general considerably less severe than in the latter. At no point as far west as the one hundredth meridian is the mean annual rainfall less than 18 inches in the Great Plains region, while, as above stated, the amount falling in the similar Russian region is nowhere more than 17 inches. At three points in the Great Plains region, viz, Bismarck, North Platte, and Dodge City, all near the one hundredth meridian, the yearly mean is normally over 18 inches, the average for the three points being 18.8 inches. The average of the normal means of the points in the Russian region, even excluding the very low figures for Orsk, is 15.9. In other words, *the normal yearly rainfall of the Great Plains at the one hundredth meridian, where wheat growing is at present practically nonexistent on account of the lack of drought-resistant varieties, is nearly three inches greater than that for the entire semiarid Volga region, which is one of the principal wheat regions of Russia, and which produces the finest macaroni wheat in the world.*

A comparison of the normal temperatures of the two regions shows the same sort of similarity, with extremes a little more severe in the Russian region. Points in the Volga region having correspondingly low winter and annual mean temperatures, always show a July temperature a little higher than those of the Great Plains region. At Orenburg, Samara, and Ufa the July temperatures are especially surprising, considering the very low winter temperatures. At Huron, Bismarck, and Moorhead are the best examples, probably, of temperature extremes in the Great Plains, but the extremes are not quite so great as at the three Russian stations.

The humidity of the air is a feature of climate often entirely overlooked, but it nevertheless has a remarkable influence upon plant growth. In the relations of climate to the development and maturity of the wheat grain there are many things not yet thoroughly understood, but the degree of humidity is known to be of the utmost importance. The exact manner in which the influence of humidity is effective—the actual changes in the plant which take place by virtue of its presence or absence—is yet to be investigated in detail, but that there is such an influence seems positive. Its effect upon the wheat plant is in general unfavorable if long continued, and particularly if it occurs near the time of ripening. Great humidity retards maturity, interferes with the production of proteids in the grain, and thereby indirectly softens it and through an overproduction of starch gives it a whiter color, weakens the straw, and presents conditions favorable for the attacks of various fungous pests. It is not so much the great precipitation that causes an inferior quality of grain in the humid areas, but the prevailing humidity of the air and lack of sunshine. Indeed, as already stated, the actual rainfall during the growing season may be nearly or quite as much in the semiarid areas as in the humid areas. Edmond Gain has stated the law in regard to this matter, viz, that "ripening is promoted in a dry air and a humid soil, but is retarded in a humid air and a dry soil."[1] It is pretty generally admitted in regard to many crops that the quality of the fruits or grains is, in some respects at least, injured by excessive humidity. It is especially true, however, of those crops which are characterized by a large proportion of protein or sugar in the fruits or grains, and in the case of durum wheats humidity is so injurious that semiarid conditions are absolutely necessary for the best results in growing them. So long

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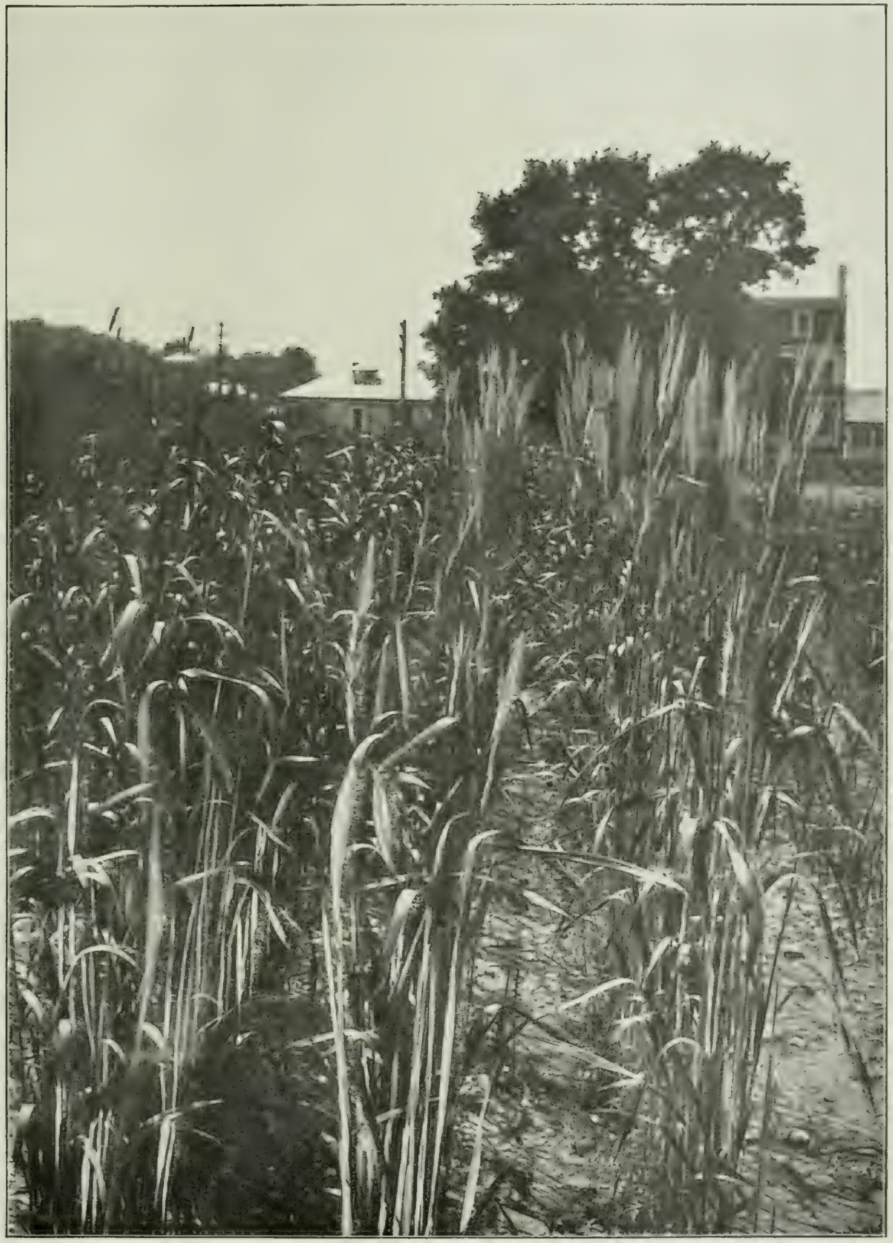
[1] Influence de l'humidite sur la végétation. Compt. Rend. 115: 890. 1892.



1. SANDOMIR. 2. ARMAVIR. 3. SARUI-BUGDA.

SARUI BUGDA IN COMPARISON WITH OTHER VARIETIES IN COOPERATIVE FIELD EXPERIMENTS AT THE MARYLAND EXPERIMENT STATION.

as the soil is of the right kind, therefore, the conditions in our semiarid plains, even near the one hundredth meridian, are not only none too arid for such wheats, but are the conditions that are *actually necessary* for their successful cultivation.

In Table II are given the absolute and relative humidity for six localities in east Russia and two localities in the Crimea, in comparison with similar data for the localities of the Great Plains, already discussed, and, in contrast with the two series, similar data for the same three places in the humid area already mentioned. The absolute humidity is given not as actual moisture content, but in the form of vapor pressure, being reckoned like barometric pressure, and is stated in both millimeters and inches. The average total number of clear days in June, July, and August is also given for as many of the localities as possible.

TABLE II.—*Absolute and relative humidity for the growing season and for the year, and the average total number of clear days in June, July, and August.*[1]

Place.	May.			June.			July.			August.			September.			Year.			Total clear days in three months.
	Absolute humidity.		Relative humidity.	Absolute humidity.		Relative humidity.	Absolute humidity.		Relative humidity.	Absolute humidity.		Relative humidity.	Absolute humidity.		Relative humidity.	Absolute humidity.		Relative humidity.	
	Mm.	*In.*		*Mm.*	*In.*		*Mm.*	*In.*		*Mm.*	*In.*		*Mm.*	*In*		*Mm.*	*In.*		
Kazan	7.1	0.279	64	9.6	0.377	66	11.7	0.460	67	10.5	0.413	72	7.3	0.287	76	5.6	0.220	77	....
Orenburg	7.3	.287	58	9.5	.374	57	11.6	.456	64	10.5	.413	64	7.3	.287	68	5.6	.220	75	....
Simbirsk	7.6	.299	64	9.9	.389	66	11.6	.456	66	10.2	.401	70	7.2	.283	75	5.6	.220	77	....
Samara	7.0	.275	54	11.1	.437	66	13.0	.511	61	11.4	.448	65	8.1	.318	73	(2)	(2)	(2)	....
Saratov	7.8	.307	59	9.8	.385	56	11.8	.464	61	10.7	.421	61	8.1	.318	65	6.1	.241	74	....
Uralsk	7.0	.275	50	9.8	.385	54	11.4	.448	53	9.9	.389	53	7.5	.295	59	5.7	.224	70	....
Simferopol	9.5	.374	70	10.9	.429	67	12.0	.472	61	11.7	.460	61	9.5	.374	69	7.4	.291	73	38
Genichisk	10.4	.409	75	12.8	.503	70	14.9	.586	70	13.6	.535	70	10.9	.429	75	8.4	.330	59	28
Eastport	6.1	.241	77	8.3	.330	81	10.4	.410	81	10.6	.420	83	8.9	.353	81	4.9	.194	76	24
Oswego	7.3	.289	73	11.1	.438	74	12.6	.497	72	12.2	.482	73	9.5	.375	74	5.6	.223	75	28
Lynchburg	10.2	.404	69	14.4	.569	71	15.9	.627	72	15.5	.611	75	12.6	.499	78	7.6	.302	71	29
Moorhead	5.9	.236	66	11.1	.437	71	12.8	.504	73	10.8	.427	71	7.8	.311	72	4.0	.159	76	29
Bismarck	6.2	.247	66	10.6	.418	70	12.1	.480	66	10.3	.408	63	7.3	.290	65	4.2	.166	71	30
Huron	6.0	.240	61	11.0	.434	66	12.3	.485	64	10.7	.425	64	7.3	.289	62	4.2	.168	69	33
Yankton[3]	7.0	.278	67	11.8	.468	71	14.0	.555	71	12.4	.492	72	9.1	.359	69	5.1	.201	69	33
Valentine	6.4	.253	64	10.1	.399	66	11.6	.459	64	10.8	.426	64	7.5	.298	62	4.8	.189	67	30
North Platte	6.7	.266	62	10.7	.421	66	12.8	.506	67	11.7	.463	67	8.0	.317	63	4.9	.197	66	32
Concordia	8.3	.327	65	12.8	.506	66	14.7	.581	66	13.7	.540	68	10.1	.400	67	6.1	.242	68	32
Dodge City	8.1	.321	61	11.8	.467	61	13.1	.519	61	12.5	.496	63	9.2	.364	62	5.7	.228	63	38
Abilene, Tex	11.6	.458	64	14.6	.575	63	15.0	.593	58	15.0	.593	64	12.8	.504	67	8.6	.339	65	42

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[1] The data for Russia are obtained from the excellent work of A. Kaminski, "Vertheilung der Feuchtigkeit der Luft Russland," pp. 34–351, St. Petersburg, 1894, and from A. Klossovski's "Contributions to the climatology of Southwest Russia, Odessa, 1899." The data for the United States is taken partly from the Annual Report of the U. S. Weather Bureau, 1896–97, and partly from unpublished reports kindly furnished by that Bureau.

[2] No figures given. All other data for Samara are meager and cover but a few years' time.

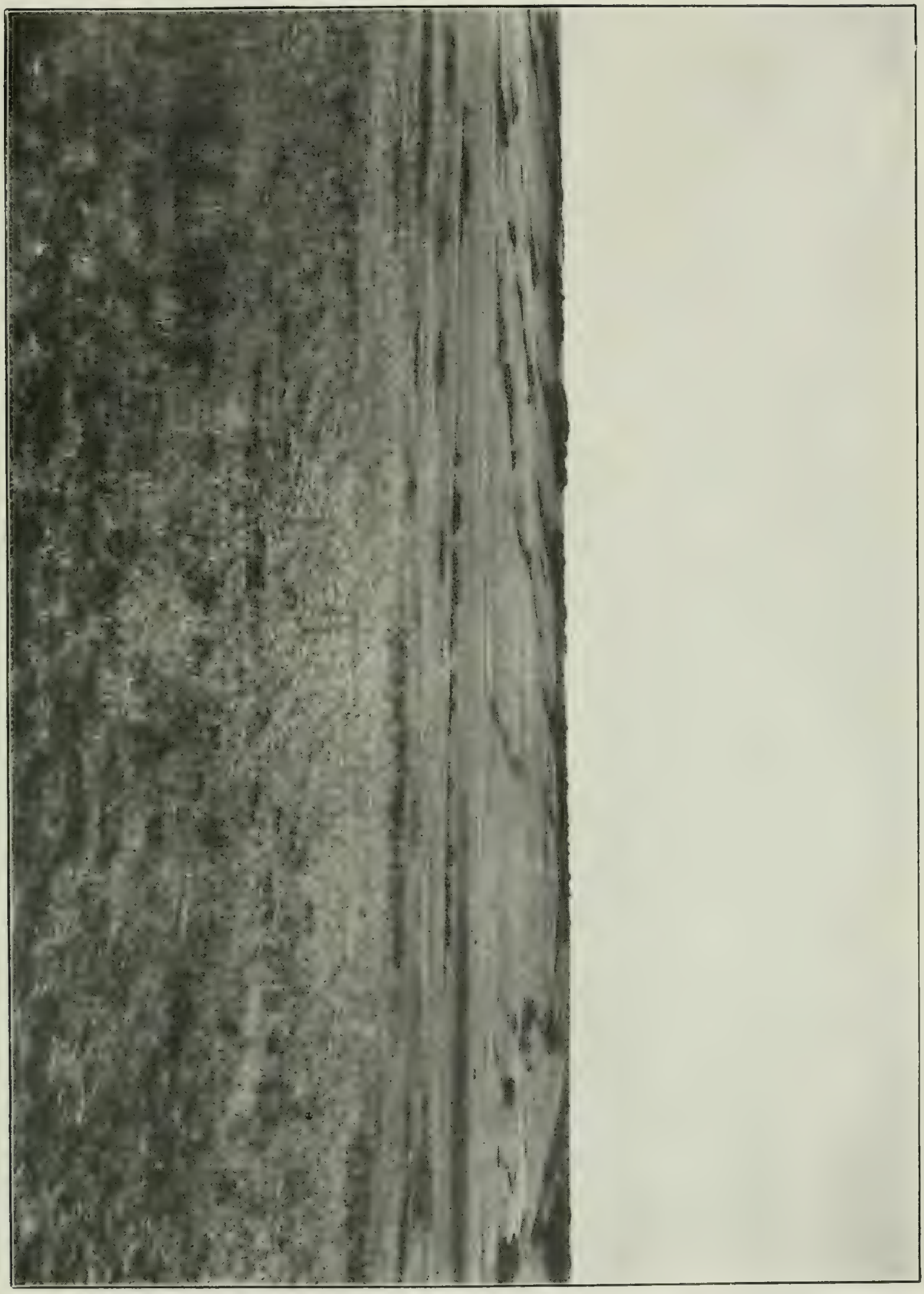
[3] Relative humidity calculated from three daily observations instead of two, as in case of the other stations.

From the table it is seen that the humidity for the summer months in the east Russian region is quite low compared with our humid area in the east, but that at the same time it corresponds very well with that of the semiarid plains region. The figures for relative humidity for a number of points in our Great Plains are very low, being all under 70. On account of the close proximity of the Russian point Genichisk to the Azov Sea its summer humidity is considerably greater than it would be otherwise. The district near to Genichisk is really quite dry and produces a good quality of Gharnovka wheat. The most interesting feature concerning humidity is that while the actual *rainfall* of the growing season in the semiarid districts is greater than in the humid area—a fact in itself interesting and most significant, as already pointed out—the *humidity* is as a rule less; that is, the rain of the semiarid districts falls in quick storms, alternating with many hot, clear days, ideal conditions for durum wheats.

The climatic features of these two regions have thus been compared somewhat in detail, since the east Russian region is at present the most important in the production of macaroni wheat and is likely to have as its strongest future rival the very similar northern Great Plains region of this country. But, as before stated, there is also a large production of these wheats in southern Russia, particularly in the region bordering the Azov Sea (see Pl. VI, figs. 1 and 2) in Kherson district and in the extreme North Caucasus. The corresponding districts of this country for which varieties from south Russia should be well adapted are the western portions of Texas, Oklahoma, and Kansas, and eastern Colorado, and perhaps portions of New Mexico, Arizona, and California. In all the south Russian region there are constant droughts and great extremes of temperature, but especially intense summer heat. On the west shore of the Caspian Sea and in the Azov Sea region the heat and drought are particularly severe, these regions being very similar in these respects to western Kansas, western Oklahoma, and the Texas Panhandle. The average rainfall from Dodge City, Kans. to Abilene, Tex., is about the same as from Kerch to Taganrog, as may be seen in the table; but the average temperature of the Azov Sea region is a little lower. In Texas, New Mexico, and Arizona the Algerian varieties will probably be best adapted for trial. In New Mexico and Arizona especially the conditions seem to be particularly suited for Algerian wheats.

COMPARISON OF SOILS.

The macaroni wheat districts of Russia lie in the well-known Chernozem or "black earth" belt, which is almost a perfect counterpart of our Great Plains in depth and richness of soil. The most thorough investigations have been given to the Chernozem soils by Russian geo-botanists, chemists, and agronomists, and many analyses



VOLGA RIVER REGION NEAR SAREPTA.

have been made, both chemical and mechanical. Mechanical analyses of a number of soil samples obtained by the writer from that country have also been made by the Bureau of Soils of this Department. All such analyses, in comparison with similiar ones made of the soils of the Great Plains, show a most remarkable similarity.

From a chemical standpoint the soils of the two regions are similarly characterized: (1) By an exceptionally large amount of thoroughly humified organic matter; (2) by the presence of an unusual proportion of phosphates, and (3) by a great amount, comparatively, of lime, potash, and other alkalies. These soils are therefore rich in base-forming metals, and are not acid, while forest soils are distinctly acid. It is well known that the substances thus more abundant in these soils than in others are just those usually needed by the wheat plant. But the indirect influence of the great proportion of lime and humus in so changing the condition of other substances as to cause them to be more easily made use of by the plant is of equal importance. Of course, the amount of soluble mineral salts present may become so great sometimes as to be really injurious to plant growth, forming actual alkaline wastes. But these are found only in certain restricted areas near the borders of salt lakes, and even in the vicinity of these wastes the very best quality of macaroni wheat is sometimes grown.

The mechanical structure of the soils is of the very nature best adapted for giving the plant the benefit of the substances contained, even under adverse conditions of climate. Humus is a great absorbent of water, and the extreme fineness of the soil particles makes it very retentive of moisture. This quality is still further increased by the presence of so much alkali. Such soils therefore retain for the growing plants a much larger proportion of the rain that falls than is possible in humid areas.

A map (fig. 1) shows the portion of the United States in which macaroni wheat may be grown. The district in which these wheats will be most successful is a comparatively narrow belt extending northward and southward through the Great Plains. Of course, the boundaries must be understood to be arbitrary and only approximately correct. One hundred to two hundred miles east of this belt macaroni wheat may give good yields and prove hardy, but the quality of grain will not be what it should. In all wheat area west of this belt the gluten content of the grain will not be so good, because of the lack of nitrogen in the soil.

EXPERIMENTAL PROOF.

After all, the most convincing evidence that a new crop is or is not adapted to the region to which it is introduced must be found in the results of actual trials of the crop in that region. Such evidence, if there is sufficient of it, must be received as final and conclusive. If these results substantiate the conclusions arrived at by a comparison of the features of soil and climate, such as we have given above, it is a gratifying confirmation of the idea that introductions of new crops

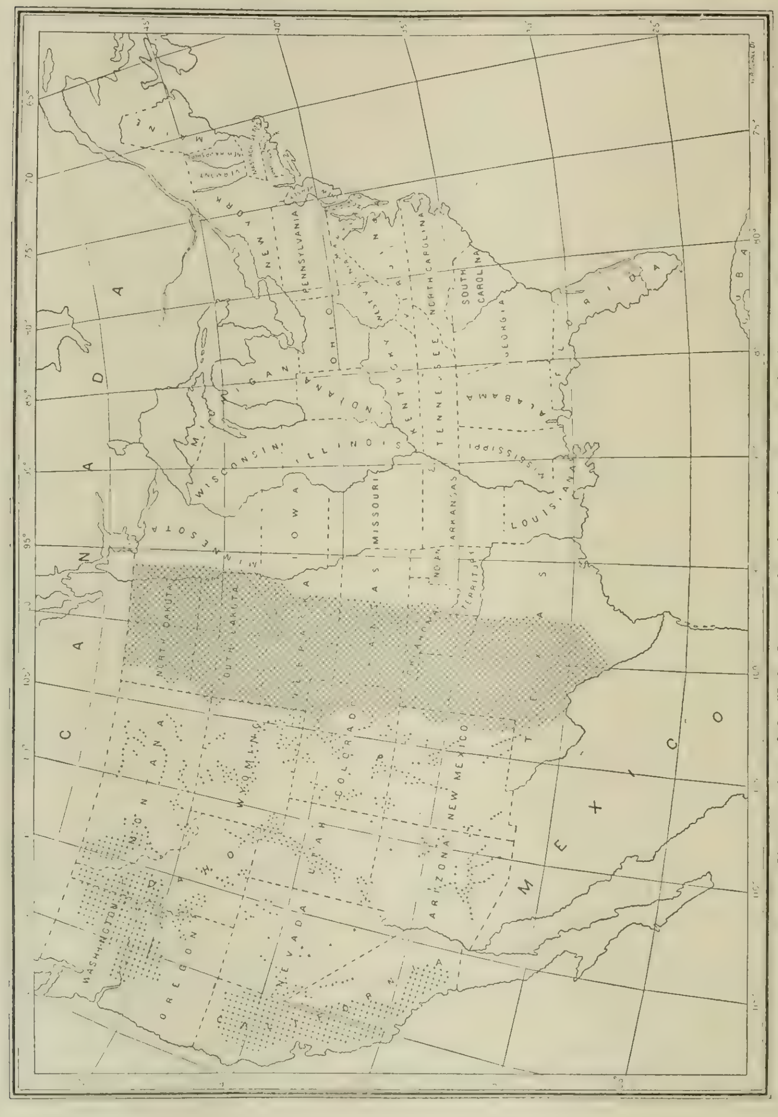

PENNSYLVANIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
LOUISIANA
TENNESSEE
KENTUCKY
OHIO
INDIANA
ILLINOIS
WISCONSIN
IOWA
MISSOURI
ARKANSAS
MINNESOTA
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
IND. T.
TEXAS
NEW MEXICO
COLORADO
WYOMING
MONTANA
IDAHO
UTAH
ARIZONA
NEVADA
OREGON
WASHINGTON
CALIFORNIA
CANADA
MEXICO
CUBA
FLORIDA

FIG. 1.—Map of the United States showing where macaroni wheat can be grown.

+++ Territory in which macaroni wheat may be grown, but the quality of the grain will not be so good.

▨ Territory in which macaroni wheat will succeed best, and without irrigation, so long as the summer rainfall is at least 10 inches.

should proceed upon the basis of a previous scientific investigation of environment.[1]

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[1] See Russian Cereals Adapted for Cultivation in the United States. Bull. No. 23, Division of Botany, U. S. Dept. of Agriculture, pp. 7–11, paragraph (1). Also the Basis for the Improvement of American Wheats. Bull. No. 24, Division of Vegetable Physiology and Pathology, pp. 7–9, 42 (top of page and note), and 81, paragraph 17.

As already stated, macaroni wheats have been introduced now and then and grown in a very few places for many years, but the growers becoming discouraged by the absence of any demand for the wheat, usually abandoned its culture soon. Nevertheless, the admirable qualities of these varieties—their great yielding power, earliness, drought resistance, and resistance to diseases—have always been noticed and remarked upon.

So far as the writer can determine, Russian macaroni wheat was first introduced into this country in 1864 by this Department. It was of the variety Arnautka and was purchased at Odessá, Russia. It was afterwards distributed annually by the Department for several years and attracted much attention because of its hardiness, early maturity, and yield. In Lincoln County, Ill., it ripened two weeks earlier than other spring wheats. In Dixon County, Nebr., it yielded 30 bushels per acre and ripened four to six days earlier than other varieties. In Minnesota it ripened a week earlier than Scotch Fife and yielded remarkably.[1] At that time, however, the possible use of these wheats for making macaroni was apparently not thought of, and their cultivation did not continue extensively. During the last three years the Department has again taken hold of the matter in a thorough and comprehensive way and with the aim to stimulate as far as possible a market, both domestic and foreign, when they are grown. A number of the very best Russian varieties have been introduced and tested systematically in comparison with standard varieties in cooperation with State Experiment Stations and certain private parties.

That the results of these experiments, both at the stations and by private parties, abundantly prove the adaptability of durum wheats to our semiarid districts is shown by the evidence which follows.

TESTIMONY OF PRIVATE PARTIES.

In Texas a great deal of attention has been given to Nicaragua wheat (Pl. I, *2*), a variety of the macaroni wheat group. One of the pioneers in experience with this wheat, formerly a millwright, and afterwards statistical correspondent of this Department, is Mr. James J. M. Smith, of Turnersville, Tex., who has often urged the importance of giving more attention to it. The following extracts from his correspondence with this Department give his testimony concerning this wheat:

> There were thousands of bushels raised here (Burnett, Tex.) as late as seventeen years ago, and a gentleman who hailed from New Orleans bought in this section about 100,000 bushels for shipment to Europe for use in making graham flour and macaroni. This wheat was hardy, and was not attacked by smut or rust, and was a sure crop, averaging from 20 to 100 per cent more in yield per acre than any other wheat. Its hard qualities make it secure from weevil or becoming musty and spoiling in vessels or elevators in transit. (Letter of October 9, 1897.)

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[1] See Annual Report U. S. Dept. of Agriculture, 1868, pp. 249, 250.

Again, in a letter dated April 15, 1898:

> Our farmers out here (Turnersville, Tex.) are well acquainted with the culture of this wheat, and the cause of their abandoning its culture was mainly twofold: (1) The indisposition of millers to handle it properly, and (2) the want of a market. The yield is certain. It tufts in winter (when sown in fall), pastures well, has a heavy straw, is easily threshed, and the best keeper of all cereals. The bread is nutritious, and for bakers' loaves it will not, after being baked, become dry and hard as bread from the softer varieties. The wheat grows sometimes as high as 6 feet and yields 60 bushels per acre. It grows well as far as Velasco, Tex., and flourishes where the tropical climate is no longer good for other wheats.

Mr. A. W. Parrott, proprietor of a stock farm at Holland, Tex., writes under date of May 24, 1898, concerning the Nicaragua wheat, as follows:

> We used to plant it here some eight or ten years ago. We made at that time from 25 to 30 bushels per acre. It would grow from breast height to the height of a man's head. It could be planted either in fall or spring. I planted 4 bushels last fall about November 15. It was very dry and the wheat did not get a very good start. I cut it last week and it will make double the yield that Mediterranean planted at the same time will make. Planted 6 bushels in February of this year. It was in full head, good stand and breast high, and will, with a good rain in a few days, make a great deal more than seed sown last fall, as there is a better stand. It is a surer crop than corn even, making on an average more to the acre than corn, besides requiring less labor to make and gather. It stands the cold better than our native wheats, thereby making a good and lasting winter pasture, and still producing a full crop of grain if not pastured too late.

The testimony of the Texas Seed and Floral Company, of Dallas, Tex. (in letter of May 24, 1898), is as follows:

> Nicaragua hard wheat was grown here several years ago, but the farmers stopped raising it on account of the millers not wanting to grind it, as it was so hard. It is very productive, and will produce one-third more than Mediterranean here, and makes splendid feed for hogs and other stock. We think it a good thing for the Texas farmer.

In 1899 this seed company kindly gave the writer the addresses of certain parties in Texas who were growing Nicaragua wheat. On request, reports were received from three of these parties giving their experience with the wheat as follows:

G. M. Givens, Lisbon, Tex.:

> I have been raising it for three years now. The first year (1896) I sowed it in December on account of getting the seed late. I got about 18 bushels per acre. The fall of 1897 I sowed 15th to 20th of October; had the finest winter pasture I ever saw, and harvested 30 bushels per acre, thresher measure, which weighed out a good deal more. My other wheat by the side of it, sown at the same time, made only 20 bushels per acre. The Nicaragua yields one-third more than Mediterranean with the same show. In the fall of 1898 I sowed Christmas week and got about 15 bushels per acre. We had no rain to amount to anything until spring. My other wheat made 10 to 12 bushels per acre. This fall (1899) I sowed Nicaragua November 10. It is a fine stand and doing well. It is a very hardy wheat, and when sown early will ripen about the same time as Mediterranean[1] or other bearded varieties. I think the proper time to sow is in October or November.

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[1] A standard red bearded wheat of Texas, and hence often referred to for comparison by Texas farmers.

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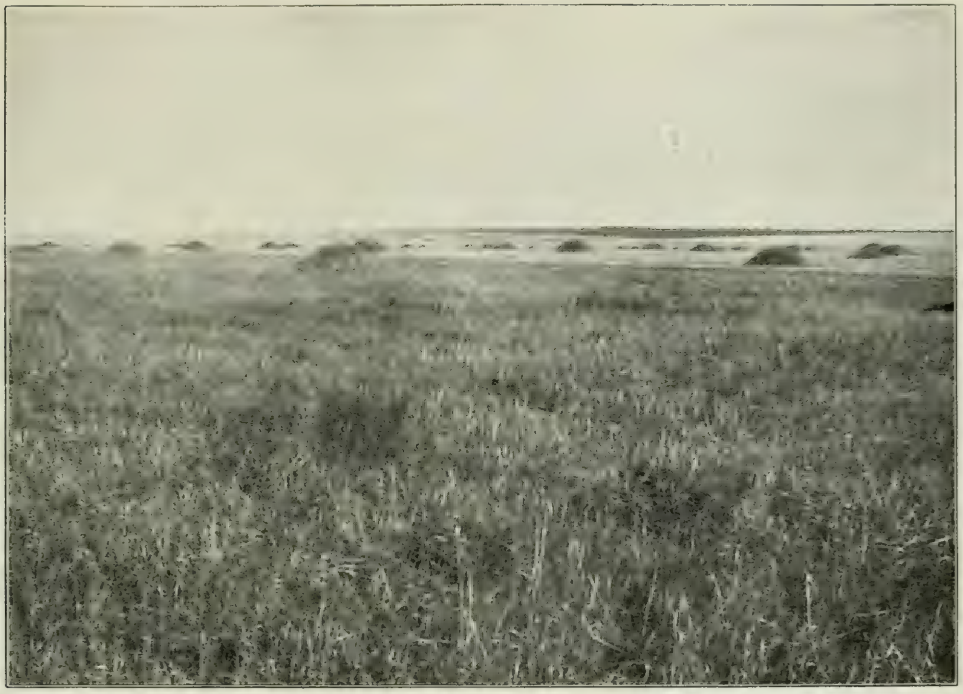

FIG 1.—MACARONI WHEAT FIELDS NEAR BERDIANSK, IN THE AZOV SEA REGION.

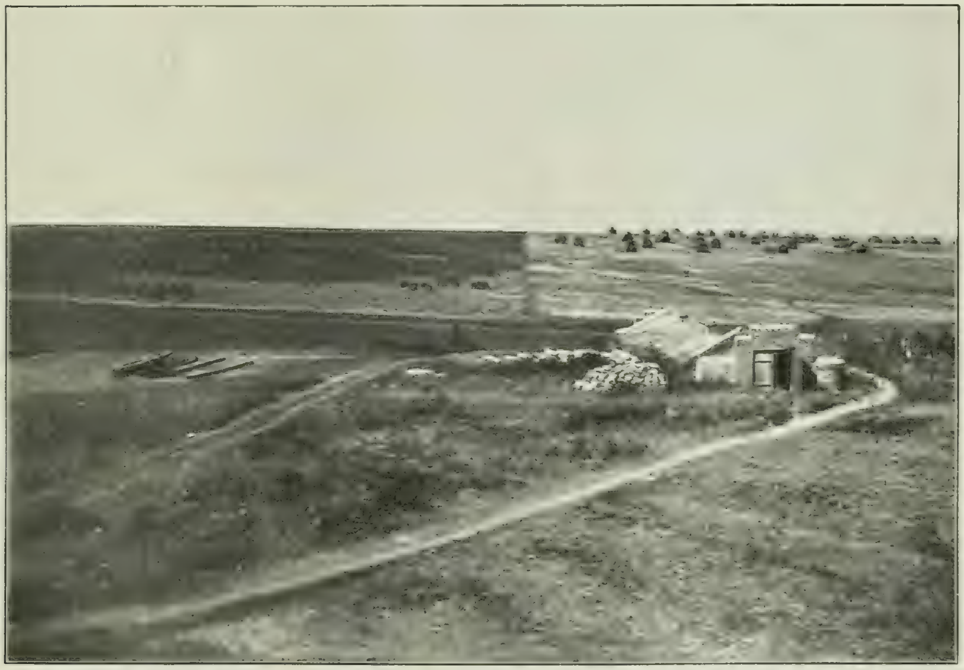

FIG. 2.—MACARONI WHEAT FARM OF MR. MIKHALKOV, AT AMBROCIEVKA IN DON TERRITORY.

N. B. Harrell, Celeste, Tex., November 20, 1899:

> It has been sown here in this section and yielded a good crop, some of it making from 40 to 50 bushels per acre.

L. L. Ayers, Gatesville, Tex., November 18, 1899:

> The wheat (Nicaragua) I sowed last year did not do well on account of late sowing and the almost unprecedented winter drought. It is a very hardy cereal, and should be sown about the time for other wheat and ripens about the same time. It is very productive in the black lands of Texas, yielding from 25 to 75 bushels per acre according to soil and season. Two years ago a farmer near Belton, Tex., raised 75 bushels per acre. It used to be raised here for hogs, but of late has fallen into disuse.

Mr. Edward K. Carr, of Kerrville, Kerr County, Tex., writes:

> The remarkable success of Nicaragua wheat, which I have sown for about twenty-four years in succession on my farm, leads me to believe that we must look to Southern latitudes for our wheat.

Concerning Nicaragua, as tried in the North, Mr. J. F. O'Grady, of Eola, Roberts County, S. Dak., writes February 14, 1901:

> I do not think the wheat had a fair trial last season, as it was a poor one for small grain in this locality. The sample was planted on April 20, the day that we finished seeding the common Blue Stem, which is the main variety used here, and Nicaragua came ripe a week ahead. Wheat averaged about 8 bushels per acre here, and the Nicaragua would have gone at least 50 per cent better.

Dr. F. W. D'Albini, of Waring, Tex., writing February 12, 1901, of results with No. 579 (variety Kubanka) of the Section of Seed and Plant Introduction, a macaroni wheat obtained by Prof. N. E. Hansen, says:

> The plants were very robust and healthy and not inclined to lodge at all. There was little rust on them, though our common wheat showed it badly. The yield was very good. I think it would have made 22 bushels to the acre.

Mr. T. N. Oium, of Lisbon, N. Dak., who has been growing an excellent quality of macaroni wheat on a considerable scale, is one of the first to secure a market for his wheat at a good price. He is growing the variety Arnautka, originally from the Azov Sea region, and has this testimony to give from his own experience (letter of May 6, 1901):

> In regard to the Arnautka wheat, will say that I have grown it for several years, and last year I had 1,000 bushels. * * * I find this wheat is admirably adapted to this country. It will yield about double what other wheat will and seems to be smut and rust proof. * * * I have succeeded in distributing enough seed so that with a normal crop I expect we will raise from 50,000 to 100,000 bushels next year. * * * Our local mill grinds flour from this wheat, and we like it much better than other flour. It makes better bread. All who use it here will use no other.[1]

The Hougen Milling Company, of Northwood, N. Dak., has not only grown macaroni wheat (of Russian origin), but has ground some of it for bread flour. The company writes as follows in a letter dated March 23, 1901:

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[1] The Arnautka wheat from North Dakota, given in Table IV, is a sample of the wheat grown by Mr. Oium. It compares very favorably with the others direct from Russia.

> We have made flour from about 200 bushels of this wheat. It takes considerable more power to grind the same quantity of this wheat than our spring wheat usually grown here. There will not be a great deal of this wheat sown here this year, as there has been no market for it. A few farmers will sow some, intending it for feed, as the yield is usually very good. We expect to put in about 100 acres of it, and in case we can find demand for the product there is no doubt a large amount of it will be raised here. The "grits" or breakfast food made from this wheat, a sample of which we send you, we think superior to that made from our native wheat.

Mr. Paul Landemann, of Scotland, S. Dak., and a former resident of Russia, has this to say in a letter of March 26, 1901, of the Arnautka wheat grown by German-Russian farmers in his section of South Dakota:

> I find that most of them have fed the last kernel of their seed to hogs on account of no market for this wheat, but everyone is happy that a market is in view, and it will take but a few years and there will be plenty. This wheat is not only good for macaroni, but it gives us a fine bread. Often in the city of Odessa I went to a well-known bakery to buy this bread, which was baked only twice a week, and found it all sold, to our sorrow. As soon as our American people will taste this bread it will find a sure market.

Concerning Kubanka wheat No. 2953 S. P. I. (Pl. I, *1*), obtained by the writer in 1898, the testimony of Mr. A. Meyerle, of Arapahoe, Nebr., is as follows:

> The wheat was planted April 26, 1899. It had one rain June 16, 1 inch, and no more rain till harvested. Harvested just seventy-six days after planting. It is so early, and that is what we want in this country.

Wheat No. 1174 S. P. I. (Pl. II, *4*), a macaroni variety obtained by Prof. N. E. Hansen from Turkestan, was tried by Mr. James Curtis at St. Thomas, N. Dak. He states results as follows:

> I planted it on the 10th of April, 1900, and harvested it on the 15th of August. Intend to give it another trial this spring (1901). It is a large plump berry and seems to be quite flinty. Grain men say that it will grade No. 1 northern.

Mr. James H. Campbell, writing from Skelton, Nev., says concerning the same variety, No. 1174:

> No. 1174 did well, better than our Nevada wheat. Planted April 1, ripened September 4. I gave the neighbors some to try.

This variety was also tried by Mr. A. B. Stanley at Echo, Umatilla County, Oreg. His testimony, given in a letter of February 12, 1901, is as follows:

> Wheat No. 1174 was sown broadcast March 26, 1900, and harvested June 29. Yield per acre (estimated), 23 bushels. The grain was large, plump, and far superior to the seed sown. I consider this variety worthy of further trial, which I shall give it the coming season. The fine stand of volunteer now on the ground, after the hard freezing weather of the last month, is evidence of its hardiness.

Mr. H. C. Warner, of Forestburg, S. Dak., superintendent of State fair, Department of the South Dakota State Board of Agriculture, has taken much interest in the trials of macaroni wheats. He experimented with Arnautka (S. P. I. Nos. 1153 and 1156) and No. 1174, and has this to say concerning results with it:

> A summary of results would be about as follows: 1153 and 1156 Arnautka were fine, withstood drought well, berry plump, color good, yield fine, ripe July 24. No. 1174 will be a good early wheat if it does not rust. Ripe July 7.

Three other correspondents report results with No. 1174, as follows:

> Alois Wallman, Crandon, S. Dak.: For durability it will prove to be the wheat best suited for the dry prairie States.
>
> H. J. Wilson, Husted, Colo.: No. 1174 was quite hardy; can not say what the yield would be, but consider it a good variety.
>
> C. A. Snodgrass, Salmon City, Idaho: It is the finest wheat I ever saw; I sowed it on the 10th of May and it was ripe on the 25th of August. It think if it were sown on fall plowing it would make a crop without irrigation, and, as to yield, I think it will yield fine. It seems to be hardy.

In Canada the Wild Goose wheat (Pl. I, *5*), a macaroni variety, which probably came originally from South Russia, has been grown considerably for several years. Mr. William Beacham, of Cambray, Ontario, writes April 3, 1901, as follows, concerning this wheat as grown in that locality:

> The straw is strong, not liable to lodge, and is not affected by rust at all. It does not shell in cutting as much as others if left till overripe. It will grow on wet or dry land and is not affected by extreme dry or wet weather.

TESTIMONY OF EXPERIMENT STATIONS.

Without any disparagement to the reports of private parties who, no doubt, state honestly the results of their experiences, it is nevertheless to the experiment stations that we must look for conclusions that are to be considered final concerning the behavior of varieties in their particular districts, as their variety tests are not only carried out scientifically and systematically, but in a highly comparative way, dozens, or even hundreds of varieties of different wheat groups being tested side by side, under the same conditions. No complete series of experiments with macaroni wheats has yet been published by any station, but several of the stations have kindly given the Department, by letter, brief reports of two-year results with the three varieties obtained in Russia by the writer in 1899, through the Section of Seed and Plant Introduction. In one instance the variety Nicaragua is also included. Fortunately, two of these stations are in the very districts to which these wheats are naturally best adapted.

The two States in which macaroni wheats have so far proved to be the most successful are North and South Dakota. The wheats not only give excellent yields in these States, but the grain produced is often apparently of better quality than the original imported seed. Prof. J. H. Shepperd, agriculturist of the North Dakota Station, reports briefly as follows the results with Kubanka and Pererodka at that station during 1899 and 1900:

I am planning to do considerable work with macaroni wheat in this district. The two best Russian sorts outranked everything else. In 1899 Pererodka S. P. I. No. 2954 gave a yield of 39.9 bushels per acre and Kubanka S. P. I. No. 2953 yielded 30.1 bushels per acre. Both were very hardy and thrifty and were early enough to be entirely safe in this district. The Pererodka made a performance of about 8 bushels per acre better than our best-bred Fife and Blue Stem sorts. I am very favorably impressed with their performance indeed. The unusual conditions of last season (1900) vitiated the results of our work with wheat to such an extent that I have no confidence in the comparative yields which we obtained from the different sorts. Pererodka was subject to very adverse conditions from drought and conditions of soil, but made a yield of 17.13 bushels per acre even with so severe a handicap. The Pererodka is a very promising sort for this section.

In South Dakota comparative results indicate very strongly the hardiness of these Russian varieties. Concerning results at the station in 1900, a very discouraging season for the entire Northwest, Prof. D. A. Saunders writes:

With reference to the macaroni wheats, Nos. 2954 and 2953 are very promising indeed. They both stood our drought wonderfully well, and yielded, in this very unfavorable season, somewhere about 30 bushels by the side of wheat that yielded 2 to 8 bushels to the acre. No. 2954 did not discolor quite as badly as No. 2953. Otherwise there is no difference between the two numbers.

Aside from their value for making macaroni and as a means of largely increasing the yield in the semiarid Great Plains, the use of these wheats will be one of the greatest factors also in the establishment of what is known as "dry farming" in the irrigated districts; that is, farming without irrigation. Prof. John A. Widtsoe, director of the Utah Station, is very favorably impressed with the behavior of Russian cereals in this respect. He has kindly furnished results of two years' experiments with these cereals in Utah, and writes as follows in regard to the matter:

In accordance with your request for a brief report on the behavior of the Russian cereals sent us by the Department of Agriculture I am pleased to inclose a copy of the report on this subject made to me by the station agriculturist. As you will observe, some of the varieties sent us have done exceptionally well. I consider that this work is of very great importance to us here in Utah, especially as regards the discovery of wheats and other grains with great drought-resisting powers. Dry farming or farming without irrigation is becoming very important in Utah. The Utah Station is in constant receipt of requests for information and recommendations concerning varieties of wheat especially adapted for dry farming.

In the report mentioned from the station agriculturist, Lewis A. Merrill, is the following paragraph:

It may be of interest to know that an exhibit was made, at our recent State fair, of these wheats, and they excited considerable favorable comment on account of the plump kernel, the color, the smoothness of bran, hardness, and general appearance.

In the following table are given the dates of seeding and harvesting, yields, etc., of the wheats only. Three of the varieties, Kubanka, Polish, and Pererodka, are Russian macaroni wheats. Romanov is also Russian, but not a macaroni wheat. The macaroni variety Nicaragua is included in the experiments of 1900.

TABLE III.—*Comparative results with wheat varieties at the Utah Agricultural Experiment Station.*

Name of variety.	S. P. I. No.	Year.	Date seeded.	Date harvested.	Number of irrigations.	Yield per acre, bushels.	Average yield.
Romanov	....	1898	Apr. 11	July 25	2	34.18	32.09
		1900	Mar. 19	Aug. 13	2	30.00	
Lamona	4276	1900	....do....	July 19	2	34.34	34.34
Pererodka	2954	1899	Apr. 13	July 28	2	36.00	34.63
		1900	Mar. 19	Aug. 13	2	33.27	
Kubanka	2953	1899	Apr. 13	July 28	2	38.42	33.59
		1900	Mar. 19	Aug. 13	2	28.76	
Polish	2957	1899	Apr. 19	Aug. 7	2	29.50	25.25
		1900	Mar. 19	Aug. 13	2	21.00	
Wellman's Fife	4404	1900	....do....	July 23	2	32.50	32.50

It is seen that the highest yield of one year, 38.42 bushels, was made by Kubanka. The yields for Lamona and Wellman's Fife are given for only one year. These are known, however, to be fairly drought-resistant varieties. Of the four varieties that were grown two years Pererodka and Kubanka made the highest average yields, these being the same varieties, too, that were so successful in North and South Dakota. Pererodka seems again to be the better of the two varieties in this case, as was found to be true in the trials of the North Dakota Station. The writer saw these varieties in the shock just after harvest at the Utah Station in 1899, and observed then that the straw was long and the heads bright and well filled, though that was the first year of their trial. The wheats were given two irrigations, but it is probable that in the most favorable localities in Utah they will produce a good average crop without irrigation.

Polish wheat (Pl. II, *1*), a macaroni variety, has been grown along with other varieties at experiment stations and elsewhere in this country at various times, and almost always with good results as regards yield, drought resistance, and rust resistance. The experiments have always been short-lived, however, either from sheer neglect or because there was no particular incentive for growing the variety. In 1891 10 acres of this wheat was planted by the Division of Botany of this Department at its grass and forage experiment station at Garden City, Kans.[1] Two hundred and forty bushels were harvested, making a yield of 24 bushels per acre, or about twice the ordinary yield of spring wheats in that State. Dr. J. A. Sewall in his report of the experiments at that station for 1891 says:

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[1] See Report of Grass and Forage Expt. Sta. at Garden City, Kans., for 1891, by Dr. J. A. Sewall, pp. 3–5. Reprint from An. Rept. Sec. of Agr. 1891.

> With reference to the experiments as a whole, I know that with fair culture in this region, without irrigation, any person can raise ordinarily a fair crop of Polish wheat, and with a reasonable amount of rainfall, a large crop. Reports on the Polish wheat distributed last winter state a yield of from 20 to 60 bushels per acre, without irrigation. The rainfall from January 1, 1891, to May 21, 1891, was only 1.41 inches. From May 21 to October 3, 1891, the rainfall was 23.20 inches, nearly 3 inches more than the average annual rainfall.

Garden City is at a considerable distance west of the one hundredth meridian. This wheat also produced a good comparative yield at the Arkansas Valley Experiment Station in Colorado, but was apparently soon afterwards discarded. It has also given good results in Washington, Utah, Iowa, and other States.

The strong resistance to leaf rust exhibited by macaroni wheats has been discussed in detail in previous publications of this Department,[1] so that no special treatment of that subject is necessary here.

In closing this topic, the results of field trials with macaroni wheats in the semiarid districts of this country may be summarized as follows: (1) Macaroni wheats are far more resistant to leaf rust than common wheats; (2) they are more resistant to attacks of smut and other diseases than common wheats; (3) in the South, when sown in good time, they furnish a good supply of winter pasturage and that without diminishing the after harvest of grain, if not pastured too late; (4) in the middle Great Plains eastern Russian varieties ripen earlier, as a rule, than the ordinary spring wheats; (5) in many places west of the 100th meridian, where wheat growing with other varieties is practically impossible on account of drought, these varieties by virtue of their extreme drought-resistance will produce ordinarily a crop of from 12 to 20 bushels per acre; by the use of these wheats, therefore, these localities may become actual additions to the wheat area; (6) in the larger part of the Great Plains where drought is less intense, but sufficiently severe to make the average yield per acre of common wheats quite low, these varieties increase the yield on an average one third or more.

THE MARKET FOR MACARONI WHEAT.

From a purely cultural standpoint—that is, the standpoint of yield, hardiness, etc., there is no question that the success of macaroni wheat growing in the Great Plains of this country is even now an established certainty. There is only the question of a market that concerns the farmer at present. It is a question, however, that ought to be capable of early solution. A market is likely to be realized in one or more of three ways: (1) By stimulating a foreign demand for the wheat for macaroni making; (2) by the development of a home demand from our own macaroni factories; and (3) by the use of macaroni wheat flour in bread making.[1]

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[1] See Cereal Rusts of the United States, Bul. No. 16, Div. Veg. Phys. and Path., Dept. of Agr., pp. 23–40, especially pp. 33 and 40, Sept. 27, 1899 (illus.); also, The Basis for the Improvement of American Wheats, Bul. No. 24, Div. Veg. Phys. and Path., Dept of Agr., in column "Resistance to leaf rust," of table, pp. 44–58, Dec. 10, 1900.

FOREIGN DEMAND.

It is already known that certain French manufacturers of semolina desire to use macaroni wheat from this country, and indeed a considerable amount of the variety Wild Goose has been shipped to France. But at present there are apparently two chief obstacles in the way of extensive foreign shipments. First, the foreign factories have not been brought through proper middlemen to see what the grower has to offer. Second, there has been no systematic effort, as there should be, to send to these factories for inspection well-authenticated samples of our best grades of these wheats, with accompanying information as to the amount that can be furnished of each.

French factories are quite ready at any time to use these wheats if they can get always a good grade. The demand for such wheat is shown by the following statements of United States Consul, John C. Covert, at Lyons, France:[2]

> It is estimated that the French output of these pastes is from 120,000,000 to 170,000,000 pounds per annum, and the product is unquestionably destined to increase greatly. To Americans it may seem strange that the power to purchase wheat foods is only now becoming general in most of the civilized countries. Thirty years ago black rye bread was universally consumed by the working classes and the peasantry in France. Bakers tell me that they all sold rye bread up to about 1870; now it is rarely found in any bakery and is eaten only in the country. * * * As the use of wheat has become more general and the power to pay for it has grown correspondingly, it is but natural that a strong tendency to seek variety in its preparation for food should exist. * * * The new and better methods for the manufacture of the edible pastes, the knowledge of just the kind of pastes certain classes of wheat will produce, and the improvements in the heating and drying processes are coincident with the sudden and widespread increase in the use of wheat foods. The continued growth of this industry will depend upon the supply of special kinds of wheat, for a decline in consumption would immediately follow any attempt to manufacture pastes of ordinary wheat.
>
> Paste makers are unanimous in the opinion that American wheats [i. e., common bread wheats] will not answer their purposes, but when one considers the almost endless variety of our soil and climate it seems that some locality must be found where a suitable wheat can be grown. What is wanted is a hard wheat [durum, or macaroni wheat, not ordinary "hard wheat"] containing a large percentage of gluten and a relatively small percentage of starch. Our wheat is lacking in both

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[1] Since the above was written facts have developed upon which a market for at least 5,000,000 bushels can be safely guaranteed for the season of 1902.

[2] Wheat for Alimentary Pastes in France. Consular Reports, 60: 468–470, No. 226, July, 1899.

these desiderata. * * * An American chemist, Mr. Edwin W. Serrell, now living near Lyons [France], has carefully investigated this subject and informs me that the wheat which is now considered the best is that grown in the neighborhood of Taganrog,[1] Russia; the next is from Algeria. That produced in southern Italy, where the manufacture of pastes originated, has lost the high place it formerly held. The best wheat grown in France—considered better than the American product—is from the neighborhood of Clermont-Ferrand.

Rapidity of growth and ripening is considered of prime importance in the production of the desired qualities in the wheat. These are the chief factors in the Taganrog product. If our farmers could produce such a wheat it would find more uses than in the *pâtes alimentaires* above referred to. There would be an excellent market in years of drought in Russia.

Millers and bakers in France have found that bread is improved by putting into it a larger amount of gluten than is found in French or American wheats, and as a consequence very hard wheats—the Taganrog generally—are mixed with the others. These wheats can not be raised in France, but must be imported, and they are the only kinds which are always sure to find a market in this country [France], as the French farming community will always demand and are politically strong enough to secure a high protective tariff on wheat and other grain.

If it be remembered that the French people eat more bread than any people in the world; that, generally, France needs very little ordinary wheat, but that she always will need a very considerable percentage of hard wheat[2] (hard is not understood in the American sense in France), it will at once be seen that there is a possibility of finding a large opening for American agricultural products in this country, not to speak of the great consumption of hard wheat in such macaroni and spaghetti-eating countries as Italy and Spain. Moreover, as the experience of the French has proved that an admixture of hard wheat, in small quantities, improves the quality of the bread, it is reasonable to infer that this practice will extend to other countries,[3] further enlarging the market for hard wheats.

The following words appear also in Consular Reports, 62: 300–301, March, 1900:

Consul Skinner sends from Marseilles, December 1, 1899, the following copy of a letter from Messrs. Bendit Leinburger & Co., 21 rue Sylvabelle, Marseilles: "We are desirous of establishing connections with some first-class American grain exporters for the importation of American hard wheat into this market; and, as our efforts in this direction have thus far met with no satisfactory results, we make free to address you the present, in order to inquire if it is in your power to place our request before the proper party in the United States.

"This description of wheat, commonly known as Goose[4] wheat, is in considerable demand in our market. It is employed by the millers in this district for the manufacture of semolina, which is used in the production of macaroni, etc. It is better adapted for this purpose than any other quality of wheat. Russia, India, Africa, and to some extent Chile have been furnishing our market with this commodity hitherto. A clear, yellow-colored, and well-cleaned wheat will always command full prices."

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[1] Nearly all Russian macaroni wheat is known in France as Taganrog, simply because Taganrog is the chief point of export. As a matter of fact some of the very best of this wheat is grown in the Volga River region.

[2] Nearly all French wheat is very soft, much softer than our wheats, but imported wheats of the durum group are mixed with them for making bread.

[3] In Eastern Russia macaroni wheats have been used in bread making on a large scale for many years, a fact not generally known.

[4] Grown rarely in North and South Dakota, but in larger quantities in Canada. See Pl. I, fig. 5.

Mr. Skinner adds: "I have already communicated to Messrs. Bendit Leinburger & Co. the facts set forth on page 400 of Consular Reports No. 230. There is no doubt that wheat of the quality described would meet with a steady demand in this market. I might add in this connection, however, that a local firm other than the one named above complains to me that certain transactions with American exporters proved unfortunate, because of the arrival of the grain in bad condition and not as represented by sample."

In 1899 Mr. James B. Simpson, of Dallas, Tex., being much interested in the statements of Consul John C. Covert above quoted, since it indicated a possible outlet for Texas-grown Nicaragua wheat, wrote this Department requesting its assistance in forwarding 2 bushels of this wheat to the United States consul at Lyons to be tested as to its fitness for use by French manufacturers of edible pastes. The letter was referred to the Department of State. It was accompanied by another letter, which was also printed in the Galveston News, and from which the following words are here quoted:[1]

Believing that the wheat exactly adapted to the making of macaroni and similar edible pastes is that hard, flinty, glutinous wheat called in north Texas the Nicaragua wheat, and seemingly almost indigenous to our black lands and warm climate, and knowing that there never was a failure in the growth of this grain in north Texas, and that such is its wonderful productiveness that an average of 50 bushels to the acre is made, I took occasion to write these facts to Mr. Covert.

Mr. Covert became deeply interested in my letter, realizing at once the great possibilities to north Texas, and referred it to M. Edwin W. Serrell, a distinguished chemist of Chabeuil, France. That gentleman wrote in reply a letter of some six pages (too long to insert here), but substantially stating that if we could grow this character of wheat a practically limitless demand existed for it in Europe, and that it could readily be shipped through Galveston.

Mr. Serrell further suggested that he be sent 2 bushels of this Texas-grown wheat for chemical analysis, which he would gladly make; and if it was as anticipated, not only could France take all produced in north Texas, but that capital would quickly come from France to Texas, putting up here establishments with a yearly output of $18,000,000.

Since I have taken up this grain matter, I have spoken with several farmers of Dallas County, who are unanimous in their opinion that we can grow to perfection in north Texas just the wheat required by this great European industry, and so satisfactory would be found the profits that our black lands would advance quickly from 25 to 50 per cent in value.

Letters of recent date have been received through the Department of State from the consuls at both Marseilles and Lyons, responding courteously to requests for certain information by this Department. In these letters reference is made again to the foreign demand for macaroni wheats. Consul Robert P. Skinner, at Marseilles, in a letter of February 6, 1901, says:

As to whether or not it would pay American farmers to export their wheats to France, I think there is no question. Buyers here are constantly looking for hard wheats comparable to those exported from Russia to this market. It has been found impossible to grow these wheats in France, and the supply produced in Algeria is quite insufficient to meet local requirements.

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[1] See "American wheat for the manufacture of macaroni," Consular Reports 61: 400, 401, No. 230, Nov., 1899.

Consul Covert, at Lyons, also makes the following statement regarding the same matter in a letter of March 8, 1901:

As to the European market for hard wheats, I am told by dealers that it will be able to absorb all that our country can produce. I know merchants in this city who would like to contract for handling large quantities of these wheats.

The foregoing statements refer to France only. Equal demands exist, no doubt, in Italy. Consul Joseph E. Hayden, at Castellamare di Stabia, Italy, also states in a letter of April 25, 1901, with reference to Italian macaroni—

In the manufacture of macaroni of the best quality a special kind of wheat is used called "hard wheat," and for the making of cheap macaroni a mixed wheat is used. This mixed wheat is neither hard nor soft. Nearly all the hard wheat comes from Russia, but some comes from India, the Orient, Tunis, and Turkey. Italy would be a very important market for American wheat, either soft or hard.

Again, in another place and more recently he gives a more extensive report on the subject,[1] as follows:

After efforts covering a period of over two years, I have succeeded in demonstrating the fact that the very finest quality of macaroni can be made of American wheat. This has been declared an impossibility by those engaged in its manufacture here, and there are hundreds of establishments in this district. Up to the present time Russian wheat and wheat from the Orient have been used, together with Italian wheat, for the production of this article of food, the American wheat being considered too soft. Through the cooperation of one of the largest establishments in this district it has been found that this conclusion was based upon the proverbial conservatism of the people. When it is remembered that macaroni consists of wheat to the extent of 60 per cent, it will be readily seen that here is an opening for American wheat of no inconsiderable importance. It should be understood that while there is a tax on American wheat there is also a tax on all foreign wheat—7.50 francs ($1.44) for 100 kilograms (220.46 pounds). It should also be borne in mind that international freights covering transportation of grain from Russia, the Orient, and the United States are practically the same.

I inclose extracts from a letter from one of the largest manufacturers in Italy and send also a sample of crude American wheat, with a sample of the wheat ground and a sample of macaroni made from the same.[2] It has been suggested to me that if the United States Government would admit free of duty, or at least at a lower tax than the present tariff, macaroni made from American wheat, a market for our wheat would be opened in competition with that of Russia and the East. The present tariff on 1,000 pounds of macaroni is $15, or 1½ cents per pound; under the plan proposed 60 per cent of the said 1,000 pounds would enter free, leaving 40 per cent to be taxed at the present rate of 1½ cents per pound, making on the 1,000 pounds a tax of $6 instead of $15. It should be remembered in this connection that the Italian manufacturer of macaroni under the scheme proposed would have to pay freight from the United States to Italy, and also pay freight on the same wheat manufactured into macaroni and transported to the United States.

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[1] "American wheat for Italian macaroni," Advance Sheets of Consular Reports, No. 1071, pp. 1, 2, June 25, 1901.

[2] The samples were transmitted to this Department together with a copy of the report. A portion of the wheat sample is true macaroni wheat, but a large portion is ordinary bread wheat, and the whole of it has been very poorly cleaned. If this makes good macaroni, as stated by the Italian manufacturer, our best well-cleaned grain will find abundant demand.

EXTRACTS FROM LETTER OF DOMENICO ORSINI.

> I send you herewith the result of my experiments in producing macaroni from American wheat. Up to this time, I am sure no Italian manufacturer of macaroni thought it was possible, believing it necessary to use a mixture of either Italian and Russian wheat, or of wheat from the Orient and Tunis. I now put in your possession the accomplished fact, which will serve to open up in Italy a wide market for American wheat. America imports macaroni from Italy, mostly from this district. The wheat used, samples of which are here inclosed, is known as "unfalcated wheat," and was purchased by me in New York City. You will notice the rich golden color of the macaroni, and as to its consistency, I would note that it can be cooked in one-half the time consumed in the preparation of the macaroni now in use.

Not only is there a great demand for such wheats in southern Europe, but American macaroni wheat has already found its way to that market in small quantities. It is chiefly the Wild Goose wheat, exported mainly from Canada. Concerning this matter the following statements are made in the report for 1900 of the Ontario Agricultural College and Experimental Farm:[1]

> There has been a considerable demand in Italy and France for the Wild Goose wheat within the past four years. One firm alone in Toronto exported in all about 600,000 bushels of the Wild Goose spring wheat in 1899. About one-half of this went to Italy and the other half to France. It is estimated that nearly 90 per cent of the Wild Goose spring wheat which is shipped from Canada is used for the manufacture of macaroni. The price of the Wild Goose for export purposes will likely vary somewhat from year to year, as our keenest competitors are Russia, India, and Turkey. If the crops of these countries are good, the quantity which is shipped from Canada is correspondingly reduced. It is thought, however, that there will be a good demand from the Mediterranean and from other continental ports for Ontario grown Goose wheat for a long time, providing the quality is good.[2]

But if such sales have been made and are being made of this Canada grown Wild Goose wheat, the prospects should be very hopeful for a constant foreign demand sufficient for the disposal of all the Kubanka and Gharnovka (or Arnautka) wheat that can be grown for several years in North and South Dakota, Nebraska, and Colorado, where the quality of the grain produced is already known to be superior, the product being much more uniform and usually free of soft grains. This leads naturally to a discussion of the necessary character of the grain required.

QUALITY OF GRAIN DEMANDED.

As already stated in another place, a clear, almost translucent, very hard, yellowish grain is, in a general way, what is required in the foreign market, just such a grain as can unquestionably be produced, too, and is being produced in the greatest perfection in the northern States of the Great Plains. It is also especially important that there shall be no admixture of soft or otherwise inferior grains, but that the entire crop shall be uniform in the quality of grain. It is because of lack of attention to these requirements and occasional careless inspection of grain in this country that there has not been even greater demand than now exists for our wheats. Consul Skinner offers some suggestions of warning in this connection which are of special value, as he is situated at Marseilles, the chief port of entry for macaroni wheat imported into France. His statements are as follows:

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[1] Twenty-sixth An. Rept. Ontario Agr. Coll. & Expt. Farm, p. 102. 1900.

[2] In a letter of very recent date Consul Skinner reports that 100,000 tons ($3\frac{1}{3}$ million bushels) of this wheat has arrived at Marseilles from Canada since March 1, 1901.

> (1) In letter of February 6, 1901: One of the manufacturers in this city has very recently been called upon to test a shipment of Goose wheat from Manitoba, and mentioned to me the other day that the result was extremely unsatisfactory, as the quality of the grain was not even, a large percentage of the kernels being sufficiently hard, and the remainder not harder than ordinary winter wheat. (2) Concerning grain inspection:[1] Three protests have been formerly lodged with me in regard to the condition of a cargo of wheat arriving from New Orleans; a like complaint has been made against wheat from Galveston, and an English trade paper noting a communication from its Marseilles correspondent, says, "We may add that London importers have been making similar complaints." These facts suggest that whatever accuracy the criticism may possess, they are not confined to an isolated case or to a single city. As my correspondents explain, wheat from New Orleans is purchased in Marseilles on the faith of the certificates of inspection issued by the board of trade of that city. The exporter appears to have no responsibility for quality of the grain beyond the production of an "official" certificate of inspection, which being in proper form binds the buyer to accept the consignment. It necessarily follows that unless the trade organizations issuing certificates exercise proper care in making the statements conform to the facts, they must lose credit and drive business into other channels.

Mr. Skinner also emphasizes the desirability of submitting standard samples of each year's crop at Marseilles in the following words:

> Many American cereals are unknown here. I have conversed with several brokers who say that if they had samples of the new American crop they could make sales. This difficulty could be overcome and a step in advance of every other grain exporting nation would be taken if our produce exchanges, notably at Chicago and New York, would send to this market annually, after the new crop is in, a complete set of standard samples. To reach the trade of Marseilles, two sets should be sent—one to the Chambre Syndicale des Minotiers et des Fabricants de Semoules de Marseille, 4 rue des Templiers, and the other to the Chambre Arbitrale des Cereales de Marseille, sitting at the bourse. The utility of the suggestion is shown by the fact that the French consul at New Orleans has forwarded some few samples to the Syndicate des Minotiers by request. Samples should be selected with scrupulous care, indorsed by the exchange sending them and sealed by the French consul, in order to be fully accepted here. The idea is applicable not only to cereals, but to cotton, oils, etc. I am extremely desirous of having this matter considered and acted upon, and will be happy to see that samples are properly placed.

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[1] Inaccuracy in American Grain Inspection. Consular Reports, 62: 303-305, No. 234. March, 1900.

In regard to the same matter of a guaranteed product being necessary to insure an extension of our wheat trade, the situation as concerns our export to Malta (where hard wheat is mainly used at present, coming chiefly from Russia) is stated by Consul John H. Grout, jr.[1] With special reference to a cargo of wheat and flour shipped direct from New York to Malta in 1899, he says:

> Unfortunately the wheat sent was not up to the standard required for military use. I have received a fair sample of it, and find it full of tares and unclean. The grains also are too small. This makes the second time that wheat from the United States has been received and each time it was below the standard. I wish to state as a result of my recent investigations on the subject, that although there is every chance for our wheat to gain this market, no headway will be made with such qualities as have thus far been received. It is utterly useless for our shippers to send wheat that will not come up to the requirements. I know that we have the required article, and it only rests with those desirous to secure a market here to send large samples first and then, if accepted, to send wheat equal to the samples. * * * Mr. Turnbull, of Turnbull, jr., & Somerville, Valleta, recently said to me: "We have large dealings with the Government here and desire to secure an American brand of wheat that will be acceptable. We desire to do business with some responsible American firm that will send us samples of wheat up to the standard, and that will, if we order from them, send us wheat up to the sample." * * *
>
> In sending samples one thing must be strictly remembered, and that is not to send poor wheat. At Malta the question is not cost, but quality. There are several good firms here that are ready to deal with our exporters. Among them are the firms above mentioned—C. Breed Eynaud & Co. and S. Scicluna & Son. The latter firm has for some time been trying to get some samples of American wheat of good quality, but thus far has not succeeded in securing what is most desired.[2]

Whatever we may think of the justness of the above criticisms, the suggestion of Consul Skinner that certified samples of each year's crop be placed with chambers of commerce at Marseilles and other ports is manifestly of the greatest importance. Such a course will be particularly effective in securing a quick market for our macaroni wheat, and the writer would urge upon our produce exchanges and boards of trade the desirability of carrying out such a plan at once after each harvest. Let the samples be in duplicate or triplicate for each foreign market, and be large enough and of sufficiently average character to represent the crop as accurately as possible. Duplicate samples with corresponding numbers should be kept by the home association, of course. Then, what is still more important, let no consignment be permitted that is not "up to" sample sent. It is absurd to think that anything is gained in making a shipment inferior to the sample on the basis of which the purchase price is paid; but, on the other hand, the entire market may be lost because of a few shipments of that kind. The importer should be able to buy by sample with positive assurance of getting just what he has ordered. The slight changes that are undergone in storage or long transportation are soon understood by the experienced dealer. In the purchase of these macaroni wheats especially no dependence can be placed upon a mere statement of grades without accompanying samples, for three reasons: (1) Because these wheats are in this country a new factor to the grain inspector, who can not yet grade them understandingly; (2) there is at present a grievous lack of uniformity in grading even our ordinary wheats; and (3) the manufacture of semolina for macaroni requires certain qualities in the grain that are not usually considered in ordinary grain inspection.

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[1] American wheat at Malta, Consular Reports, 60: 479, 480, No. 226, July, 1899.

[2] For further discussion of this subject see testimony of Frank H. Hitchcock, Chief, Section Foreign Markets, before the Industrial Commission; Foreign Markets for American Agricultural Products, Rept. No. 67, U. S. Dept. Agr., Washington, 1901, pp. 32–42.

In all tests that have so far been made of American macaroni wheats by the semolina manufacturers of France the results have been fairly satisfactory, it being stated in several instances that the semolina is fully equal to that of the Taganrog wheats. But these tests have been made almost wholly with Texas and Canadian wheats, which are apparently inferior to those grown in the northern and middle Great Plains. The writer firmly believes that when the North and South Dakota macaroni wheats shall be thoroughly tested in foreign factories they will be acknowledged to equal in quality any other wheat of that kind in the world.

In an article entitled "Wheat for edible pastes in France," Consul Covert reports to the State Department[1] the results of tests made of the 2 bushels of Nicaragua wheat sent to him by Mr. James B. Simpson, as already noted.[2] Messrs. Gilibert & Teziers, Valence, France, reported upon a package sent them as follows:

> Macaroni can be made out of this wheat, but of an ordinary quality, because it can not contain a great deal of gluten. It contains considerable soft wheat, and some of it is *mouchetés;* that is to say, black about ends. It seems to us that wheat more evenly hard and not *mouchetés* ought to be grown in Texas. The wheat which we want would bring at Marseilles about 18 francs ($3.47) per 100 kilograms (220.46 pounds).

Another package sent to Mr. Edwin W. Serrell, at Paris, was given to an expert for examination, who reported as follows:

> ITS FORM.
>
> Long grains, indicating a high average of gluten. A horny or corneous form; the best variety of hard wheat. It is, in fact, very hard.
>
> Grains regular in size.
>
> But very little impurity; a few grains of tender white wheat.
>
> Unfortunately there are a few spotted grains. This defect, which ought not to be inherent in the quality, diminishes the value somewhat, for it will necessitate more time for sifting to eliminate the black spots from the semolina.

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[1] Wheat for Edible Pastes in France. Consular Reports. 62: 301, 302. No. 234. March, 1900.

[2] Page 31.

ANALYSIS OF THE GLUTEN.

Paste very rapidly obtained.

Gluten very easily separated; very homogeneous and elastic. The analysis shows damp gluten 30 per cent; dry gluten 10 per cent.

These proportions occur only in the superior grades of hard Russian wheat.

With well sifted semolina there could be made from this wheat edible pastes carrying 13.33 per cent of gluten. This wheat would therefore make the best qualities of edible pastes.

Mr. Covert adds:

> The above report coming with Mr. Serrel's indorsement should leave no doubt as to the value of pastes, for no man in Europe is more competent than he to pronounce an opinion on this subject.
>
> The gentleman to whom I sent specimens of this wheat in Marseilles reported verbally that it would find a ready market in that city at 16 francs ($3.08) per 100 kilograms. Dealers have been one week investigating this subject in Marseilles. Their first report was favorable. This morning they confirm the first opinion.

While the above reports are in the main favorable, the considerable number of grains with black ends is a detriment. These grains were noted by the writer in samples from the same source sent to this Department for the Paris Exposition of 1900, and were at once considered to be the result of being grown in a locality a little too damp. In Russia macaroni varieties when grown in a locality too damp likewise deteriorate in the same manner. The use of Taganrog wheat for seed in Texas, as suggested by the French manufacturer,[1] would therefore probably make little difference. The defect will no doubt best be overcome, as the writer has before suggested, by growing the wheat farther westward, in the region between Wichita Falls and Abilene. The present Nicaragua wheat area in Texas, if extended over one-half its width westward, would furnish a quality of grain much superior to what it now produces. At the same time it would add to the general wheat area of the State thousands of acres of semiarid lands at present supposed to be unsuited to wheat culture, but which would yield a good average crop of this wheat because of its drought resistance. The writer has observed that this wheat, when grown in eastern Colorado or extreme western Kansas, produces a grain as clear, hard, and yellow as the east and south Russian wheats.

As the traffic in macaroni wheats increases it will be necessary to construct special elevators for handling them. It is plainly impossible to handle these wheats and the common wheats together, as each would ruin the other by the mixture. There ought to be, and probably will be, a sufficient amount of these wheats grown in the next five years to justify the construction of several large terminal elevators at such points as Galveston, Chicago, and Minneapolis, in addition to various smaller local elevators, all of which will handle only macaroni wheats.

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[1] See "Wheat for edible pastes," by John C. Covert, Advance Sheets of Consular Reports, No. 668, pp. 5, 6, March 3, 1900.

POSSIBILITY OF A HOME DEMAND.

While the prospects are very good for a foreign market for these wheats sufficient to utilize probably all that we can produce for several years, an excellent market is also likely to be developed sooner or later in our own macaroni factories. At present all these factories, with rare exceptions, use the flour of common bread wheats in their operations. Of course this is chiefly due to the fact that heretofore it has been impossible to obtain true macaroni wheats in this country, and it is considered impracticable to import them. Most of the factories realize the importance of using the semolina of such wheats as soon as they can obtain it in sufficient amount and of good quality. It will certainly be of the greatest advantage to the factories as well as to the growers to establish trade between them in the use of these wheats. The factories will thus be able to obtain either the wheats or semolina made from them at much less cost than the imported material, and the farmers will have the benefit of a quick home market.

Another strong advantage in using these wheats in our own factories, and which especially affects the consumer, lies in the fact that the homemade product, other conditions being equal, is always much better from the standpoint of simple freshness. We all know how much better fresh bread is than old, and what a nutty flavor newly-made flour gives to the bread. These facts apply with even greater force in macaroni making. All imported macaronis must of necessity have lost a large per cent of their flavor, and as the homemade product is made almost entirely from common wheats, it follows that the majority of American people really have never tasted the very best macaroni.

More than all else the use of macaroni as a food is far from general in this country, and should become more popular. It is a comparatively rare food with us. As already quoted in another place, in France alone the annual output of edible pastes is estimated at from 120,000,000 to 170,000,000 pounds. A considerable amount of this is of course exported, but there remains an enormous amount which is consumed in France. These pastes are among the most common and popular foods in that country. The same may be said of Italy. Let a sufficient amount of good wheat be grown and our factories begin producing from these wheats its best article possible, in a variety of forms, and there is no good reason apparent why such foods should not soon rank in popularity with our breakfast foods.

Concerning the question of a home demand for macaroni and macaroni wheats, Consul Skinner writes as follows:

> While the cultivation of a hard wheat suitable for the manufacture of macaroni for export to Europe is a matter of great importance to our people, I consider of equal importance, if not greater, the creation of a demand in the United States for a macaroni for domestic consumption. Macaroni in southern Europe takes a hundred different forms, and constitutes a staple article of diet that is cheap and palatable. Its

possibilities in America are quite unknown, and macaroni in its most ordinary form is consumed in a very small number of families. Nor are these facts the result of popular ignorance entirely, for macaroni and semoule, to be good, should be manufactured in the country of consumption, as the deterioration in quality sets in even a few weeks after production. It necessarily results from this that the macaroni exposed for sale in American shops and imported from Europe is stale and tough, and therefore little in demand. I have no doubt you have seen, as I have frequently, large cases of bulk macaroni exposed to the air for weeks in small grocers' shops. What is true of macaroni is still more so of the semoule or flour from which macaroni is produced. This flour is in a moist state, and could not be used by the French manufacturers of first-class macaroni two months after grinding, and in most cases goes directly from the mill to the factory. A few importers do succeed in packing semoule in tight cases, but even with these precautions it loses much, and the demand for it in the United States is trifling indeed.

Similarly, Consul Covert makes the following statement:

But an important market ought soon to be created for them (macaroni wheats) in the United States. The edible paste factories make paste of hard and soft wheats with the same machinery. Soft wheat, however, is most used in Belgium and in the Vosges, a department in France. The best pastes are made with hard wheats. The use of edible pastes is steadily increasing in Europe and there is no reason why the same should not be true of the United States. It is a common article of food in the wealthy families of this country and is of daily use among the poor. It is cooked with meat, cheese, vegetables, and in various forms used in soups and sauces. The French paste makers are said at present to lead the world in this product, and if Americans expect to obtain the custom of our country which now goes to France they should lose no time in using only hard wheats. The same identical machinery is used whether the wheat is hard or soft.

KINDS OF WHEAT NOW USED BY OUR FACTORIES.

There are at least fifty rather large macaroni factories known by the writer to exist in the United States, and no doubt there are many others. With a number of these factories the Department is in regular correspondence, and has found the manufacturers, with few exceptions, to be fully awake to the advantages of using macaroni wheats and desiring to obtain semolina from such wheats wherever they can do so. In the absence of such wheats it is interesting to know that they almost invariably use the very hardest red wheats that are grown in this country, chiefly Kansas hard winter and the hard spring wheats, which is in itself virtually an admission on their part that the harder the wheat the better. The following extracts from a few letters show fairly well the trend of opinion among the mills and factories along this line:

(1) We are now using a mixture of hard Kansas wheat and the hardest grades of winter wheat that we can obtain in this vicinity for our macaroni purposes. This makes a fairly good article of macaroni, but we have no doubt but that the true macaroni wheat would make a superior article. We have never been able to obtain the same, and if we could now get a supply of this wheat we should be very glad, indeed, to do so. Any information that you can give that would assist us in getting this wheat would be highly appreciated. * * * In the meantime could you tell

us where the name Arnautka[1] wheat comes from. We had never before heard of wheat under that name, but recently have had some correspondence with a party in North Dakota who raises a wheat called Arnautka, and from a sample we are satisfied that it would be just what we wanted for macaroni purposes. (2) I have given the subject of macaroni flour special study, and as a result have on hand more than twenty different samples of wheat flour sent me from Europe. In my estimation there is nothing like it raised in this country, and I am certain that if it should be raised there would be a good market for it among macaroni manufacturers. We are using at present the bread flour manufactured by the Minneapolis mills, which gives very satisfactory results, but not equal to the imported Italian macaroni. There is no question in my mind that if the American farmer produces it he will receive a premium for the right kind of wheat for macaroni. Kindly inform us where this particular wheat is being raised in the United States, and in what quantities. If at any time you come across an enterprising miller who will grind macaroni wheat and is willing to cooperate with the manufacture of it into macaroni, kindly refer him to us. We will be always ready to manufacture from that high grade of wheat. (3) We are using in our factory flour, and have also used farina, which we get from districts where they raise the hardest spring wheat, and the result has been very satisfactory, it being equally as good as the imported. (4) We find the flour which gives us the best results is that which is made from wheat grown in northern Kansas. This wheat is very hard and contains a very large percentage of gluten, which is necessary for a good macaroni. (5) I only use in the manufacture of the goods the best grade of spring-wheat flour, preferably of Minnesota wheat. (6) We agree with some other manufacturers that so-called Taganrog wheat is slightly superior to the American wheat, it having more gluten; and again we know it to be a fact that a hard spring-wheat flour, if properly used, produces goods that are equal to imported and only an expert can tell the difference. * * * We are using the high grades of spring and winter wheat flour. (7) We are using the ordinary bread wheats called "Kansas hard wheat" for the manufacture of macaroni, which has proven quite satisfactory, but not of a quality equal to the true macaroni wheats. * * * The macaroni wheat is, of course, much superior to the ordinary bread wheat in the production of macaroni, and if the flour could be produced at a reasonable price a much superior article could be produced and the industry stimulated in a corresponding degree. (8) We would be only too pleased to use it (macaroni wheat) in preference to other wheat flour; for we feel confident that with the improved American method, and using Taganrog flour, the American product would be superior to the imported article now used in this country, and we heartily approve of your ideas in experimenting and raising an American product. (9) All the manufacturers here of macaroni and all grades of the Italian paste, with the exception of one, use the grade of flour manufactured from wheat grown in the arid section of northwestern Kansas and known as the Russian hard winter wheat. * * * Macaroni made from ordinary wheat will not do. This has been demonstrated time and again. Of course macaroni can be made and the goods will have a limited sale; but to insure success in that branch of manufacturing industries the quality of wheat must be such as to insure satisfaction to the patrons. We have an idea that the wheat which was introduced here some time ago from Nicaragua, and which was turned down by all the mills that had given it a trial as being worthless, is just the quality adapted to the manufacture of macaroni.

The above reports are from some of the most prominent manufacturers in that line in the principal cities where this industry is carried on.

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[1] As mentioned in another place, this variety is a macaroni wheat already grown to a slight extent in North and South Dakota, and which came originally from Russia. The derivation of the name is uncertain.

COMPARISON OF FOREIGN AND DOMESTIC MACARONI.

It is rather difficult for one who is not an expert to compare the American and foreign products, especially since the foreign is necessarily quite old before it can be obtained, and therefore has deteriorated more or less. There are in general these differences, however, which are usually quite distinct: (1) The foreign is yellowish, the domestic white or grayish white; (2) the foreign is more vitreous in fracture than the domestic; (3) the foreign preserves its shape longer in cooking than the domestic; (4) the foreign is more elastic and not sticky in chewing like the domestic. The word foreign must be understood here to apply to the best French and Italian products made from true macaroni wheats. Of course there is a considerable amount of foreign pastes made from soft wheats and really inferior to our own products. In actual kitchen trials of various samples it will be found that the product made from our hardest bread wheats, by virtue of improved methods of manufacture, is really very good, but always falls a little short of the foreign in quality. This being true, it is possible that our best factories, using true macaroni wheats as grown in this country, would produce an article superior to the best foreign product.

In the following table are shown such differences as exist between a number of various grades of macaroni from a chemical standpoint:

TABLE IV.—*Analyses of macaroni produced from different wheats, results expressed as percentages.*

Name of product.	Kind of wheat from which made.	Moisture.	Fat.	Crude fiber.	Ash.	Protein.	Carbohydrates by difference.
Egg noodles	Hard spring (with eggs)	9.27	4.36	0.31	0.71	15.63	69.72
Spaghetti	Bread wheat, kind unknown.	9.55	.47	.71	.57	12.63	76.06
Macaroni	do	10.20	.38	.52	.61	12.31	75.98
Do	Kansas hard winter	10.36	.38	.57	.51	12.06	76.12
Do	Dakota and Minnesota	10.24	.43	.37	.43	11.06	77.47
Spaghetti	do	10.15	.44	.37	.44	12.63	75.97
Mezzani	Minnesota spring	10.20	.22	.38	.32	12.56	76.32
Macaroni	Hard bread wheat	10.19	.42	.37	.43	13.88	74.71
Spaghetti	Hard spring	10.15	.19	.40	.56	13.44	75.26
Do	Kansas hard winter	10.06	.56	.35	.47	12.56	76.00
Macaroni	do	10.06	.46	.49	.45	12.63	75.91
Macaroni (artificially colored).	Hard spring	9.44	.26	.46	.67	13.25	75.92
Macaroni	Mixed hard and soft bread wheat.	9.58	.19	.53	.83	14.75	74.92
Do	Mixed Kansas hard and ordinary winter.	9.79	.49	.38	.63	12.63	76.08
Macaroni (splits easily).	do	10.00	.40	37	.62	12.75	75.86
Macaroni (very large).	Hard bread wheat	9.73	.45	.38	.48	14.06	74.90

TABLE IV.—*Analyses of macaroni produced from different wheats, results expressed as percentages*—Continued.

Name of product.	Kind of wheat from which made.	Moisture.	Fat.	Crude fiber.	Ash.	Protein.	Carbohydrates by difference.
Macaroni (genuine Italian imported).	Unknown	10.05	.24	.50	.65	13.06	75.50
Macaroni	Grown to order	9.91	.49	.39	.44	12.06	76.71
Do	Pillsbury's best flour	9.61	.58	.38	.43	13.81	75.19
Do	True macaroni wheat grown to order.	10.50	.75	.22	.50	17.13	70.90
Mezzani	Imported Taganrog	10.25	.58	.22	.64	10.19	78.12
Macaroni	Best Minnesota spring	10.29	.67	.23	.43	12.38	76.00
Macaroni (genuine French imported).	Unknown	10.02	.39	.25	.71	12.25	76.38
Mezzani (genuine Italian imported).	American mixed durum and bread wheat.	10.88	.41	.23	.53	11.50	76.43
Macaroni	Bread wheat, kind unknown.	11.88	.40	.27	.52	10.06	76.87

These analyses were made by the Bureau of Chemistry of this Department, and include 21 domestic samples of macaroni and spaghetti, a sample of French and two of Italian production, and a sample of egg noodles. As already mentioned, it will be noted how much of these pastes is made from our hardest bread wheats, in the absence of the proper durum wheats. It is an indication of the fact that the very hardest wheats are required, and therefore the sooner the real durum wheats can be obtained the better for the factories. Comparing this table with Table V it is seen that the average protein content of these samples is considerably less than that which could be obtained from true macaroni wheats if they were used instead. The difference is even greater than here shown, however, since in Table V only the albuminoids are given, while in Table IV the entire protein content is given. In connection with these facts it is interesting to note that the one sample, only, made from true macaroni wheat,[1] shows a protein content at least 2 per cent higher than the best of the others, and a correspondingly low percentage of carbohydrates. The protein content of the egg noodles is of course increased by the addition of egg. Of still further interest, and much importance to us, is the fact of the high protein content of the Arnautka wheat from North Dakota, mentioned under remarks in Table V.

The gluten content of these macaroni samples was also determined, but on account of the great changes in the gluten effected in drying the macaroni during its manufacture, these results are entirely misleading and of no value in this connection.

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[1] The writer has examined this wheat and knows it to be a good quality of real durum wheat. It is the only instance in this country known to the writer where macaroni is already being made from durum wheat, though one other factory is preparing to put out a product from the same class of wheat.

PREPARATION OF SEMOLINA.

Macaroni factories, with few exceptions, obtain their flour or semolina already prepared. In this country, while the bread wheats are being used, it is a comparatively simple matter, the flour being obtained from the ordinary flour mills. In Marseilles the preparation of semolina has become a special industry, and large establishments for this purpose have been formed, which stand in the same relation to the macaroni factories there that the flour mills here do to our bakeries. It has thus become an easy matter for the factories there to secure material ready prepared and always of just the right grade for the best macaroni.

In this country just now, in connection with the development of the macaroni industry, one of the greatest needs is for a few enterprising millers to begin this same business of specializing in the manufacture of semolina from true macaroni wheats, in response to the demand that already exists among our own factories. To make the matter a success it should be begun in direct cooperation with certain factories who would agree to take all the semolina the mills could furnish, provided it were always of the grade required. It is known to the writer that a number of factories would be glad to do this. On the other hand, with due notice of such a movement to the farmers and grain dealers, the necessary supply of excellent wheat will be forthcoming in good time; in fact, will probably be ready in sufficient amount for a good beginning after the coming year's harvest. At the same time there is probably opportunity for considerable business in the sale of miscellaneous products from these wheats, such as flour for bread making, grits for breakfast foods, etc.

Millers have usually been deterred from operating with such wheats because of the idea that it would involve too radical a change in their methods in proportion to the profits that would likely follow. It is probable, however, that the difficulties in the work are greatly overestimated. From testimony of those who have investigated the matter, it appears that the important thing is to know the nature of the semolina required. This being known, the methods of producing it are learned by practice, and may be carried out it seems, simply by the addition of moisture and slight modification or arrangement of the ordinary milling machinery used in making bread flour. Consul Skinner says concerning this matter:[1]

> The devices required for producing semoule are essentially the same as those essential to the grinding of first-class flour, the main difference being that the grinding is less fine and that moisture is introduced.

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[1] In letter already quoted.

The following statements are quoted from a paper by Mr. Edwin W. Serrell, of Paris, an authority in this line, and transmitted to this Department through the Department of State by the courtesy of Consul Covert:

> Any American grist mill fitted with modern machinery can be made to do the work if properly handled. * * * The manufacturers in America have been making inferior pastes from soft wheats, and the millers may be trying to turn out something which is not the thing wanted for paste manufacture. If they have been trying to turn out *flour* for this purpose, then it is certainly the case, for flour is not what is used for the manufacture of high-grade edible paste. * * * Unless I am very much mistaken in so far as milling is concerned, what is needed, and the only thing needed, is a definite knowledge on the part of the millers of the exact nature of the product to be turned out, and of the arrangement of their existing machinery best adapted to its production. I may add that I think only very slight changes of method would be needed in American mills to enable them to turn out what is wanted, and that such changes would be rather in the operations than in the machinery.

BREAD FROM MACARONI WHEATS.

Aside from the use of macaroni wheats in paste making, the writer is confident that a large demand is in store for these wheats in future for bread making, not only in foreign countries where they are already seeking for such wheats for bread, but in this country as well. Let the use of these wheats once become general for making pastes and the people will soon discover their excellence for bread making as well. The evidence from actual experience in favor of these wheats for bread from the standpoint of both taste and nutrition is too great to be longer ignored. On the other hand, the objection to their use in this way from the standpoint of difficulties in milling operations will soon be found to be not well taken. If they are properly handled they can be readily ground into bread flour, though in some instances it may be found advisable to mix a small percentage of hard red wheats with them. There is no good reason why the much despised "Goose" wheat of the Northwest may not yet rank well with the Fifes and Blue Stems even in the production of bread flour. At least four prominent flour mills in this country are now known by the writer to be grinding these wheats, and in absolutely every case of those so far known to the writer where bread made from the resulting flour has been used the parties now prefer it above all other kinds. It is found also that the grits made from these wheats make excellent breakfast foods.

By far the largest amount of bread flour from macaroni wheats is manufactured in the Volga River region of East Russia, the native home of the best varieties of these wheats, and it is in this region that the use of such flour for bread was first practiced on an extensive scale. Besides being one of the largest wheat regions of Russia, it is also one of the most important milling districts, and yet a large proportion of the wheat used in most of these mills is the variety Kubanka, a macaroni wheat. The mills are fitted in the most modern style with the Hungarian system of rolls, but invariably possess steaming machines for moistening and softening the grain. The bread of that region made from this wheat has become very popular, and the visit of every foreigner who is a lover of good bread increases its reputation. The famous bread of Moscow called "Kalach," as well as several excellent kinds in Odessa, are made from this wheat. There is a certain richness of flavor in such bread not found in other bread. But probably the most important quality is that it will remain palatable so long, not drying out readily nor becoming stale. The color of the flour and bread is yellowish, and indeed the preferred color of bread in east and southern Russia, and to a great extent in France, Greece, and Italy, is yellowish and not white.

It will be proper to close this topic with a few remarks on the use of macaroni wheat flour for bread in France and the possibilities of extension of our foreign markets for wheat and flour in case we should grow this kind of wheat. Quoting still further Consul Skinner's letter, he says:

> French bread to be satisfactory must be made of mixed flour, and consequently until popular taste undergoes a radical change, and irrespective of the amount of wheat grown in France, there will always be a market for a really hard wheat, in the first place to supply the requirements of semoule manufacturers, and in the second place to supply flour for mixing. What is true of France is largely true of the entire Mediterranean country, and the farther East one goes the greater is the desire for hard wheat. In Greece, for example, the bread is manufactured exclusively from hard wheat, and there is a pretense that it is more nutritious and palatable on this account. It has the further advantage of remaining fresh for a longer period, being said to be as good at the end of a week as the day after baking. Right here in Marseilles a special loaf is manufactured for sandwich purposes, and the delicate slices, I know from personal experience, remain fresh for from twelve to eighteen hours after they have been cut. My recollection is that our American bread hardens very promptly after the loaf is cut.

CULTIVATION OF MACARONI WHEATS.

In a general way the methods to be employed in the cultivation of macaroni wheats are similar to those required for the best results with any other wheats. Early plowing, thoroughness in preparation of the seed bed, early seeding, and all those other principles of prime importance in general wheat culture are perfectly applicable in the culture of these wheats. The chief thing to be kept in mind is that with macaroni wheats some of these principles need special emphasis. Since these wheats are to the farmer of special value for growing in semiarid districts, the principles needing particular emphasis are the same that are to be observed in all wheat growing in such districts.

PREPARATION OF THE SOIL.

As rapidity of growth and ripening seems to be one of the requisites for the production of a good macaroni wheat grain, these wheats are pretty generally used as spring wheats, for in districts of short hot summers the winters are usually too severe for growing winter wheats.[1] All plowing should therefore be done the previous summer, if the wheat is not to be sown on a summer fallow. The plowing should be rather deep. Then afterwards it should be lightly cultivated once or twice before winter. It is particularly important to disk lightly or harrow as soon as practicable after a heavy rain. After the alternate freezing and thawing of the winter and further spring cultivation, the ground will be in excellent condition for seeding. Seeding should be done as early as possible, just as soon as the ground can be put in good condition after the frost is out. Early seeding will promote early ripening.

METHODS OF SEEDING.

All the tillage of the ground after the original plowing, up to the time of seeding, should be such that only the portion near the surface is cultivated, while the portion below remains compact and in condition to hold as much moisture as possible. All experience in wheat culture is so full of evidence in favor of the use of the drill, that it is hardly necessary to say that seeding should be done with that machine. There is special reason, however, for seeding only with the drill in growing these wheats in semiarid districts, and not only that but for the use of a particular kind of drill. It must be remembered that we are preparing to resist drought—possibly intense drought—and while we are using drought-resistant wheats, which will make all the better grain, too, because of the drought, yet in order to make a crop at all we should aid the wheat by taking all the steps possible to conserve and utilize the little moisture that falls. A drill should therefore be used which is a sort of combination of the press and lister drills. That is, in addition to the listed furrow, the grain should be put down still deeper, and the soil compacted around it as in case of the press drills. Then the depth of the furrow and the fine dirt rolling in from above will combine to protect the moist earth below from evaporation, and at the same time the dry south winds will not be able to blow the dirt away from the roots or what is worse blow the wheat itself out of the ground. The rate of seeding per acre should be about the same as with other wheats. These wheats do not stool as much as ordinary wheats, but produce all the better heads by not doing so.

CARE IN HARVESTING.

It is important for producing a perfect quality of grain that macaroni wheats should be harvested at just the right time. They should be entirely ripe, and harvesting should not be done in damp or even cloudy weather, if it can be avoided. The brighter the sunshine and

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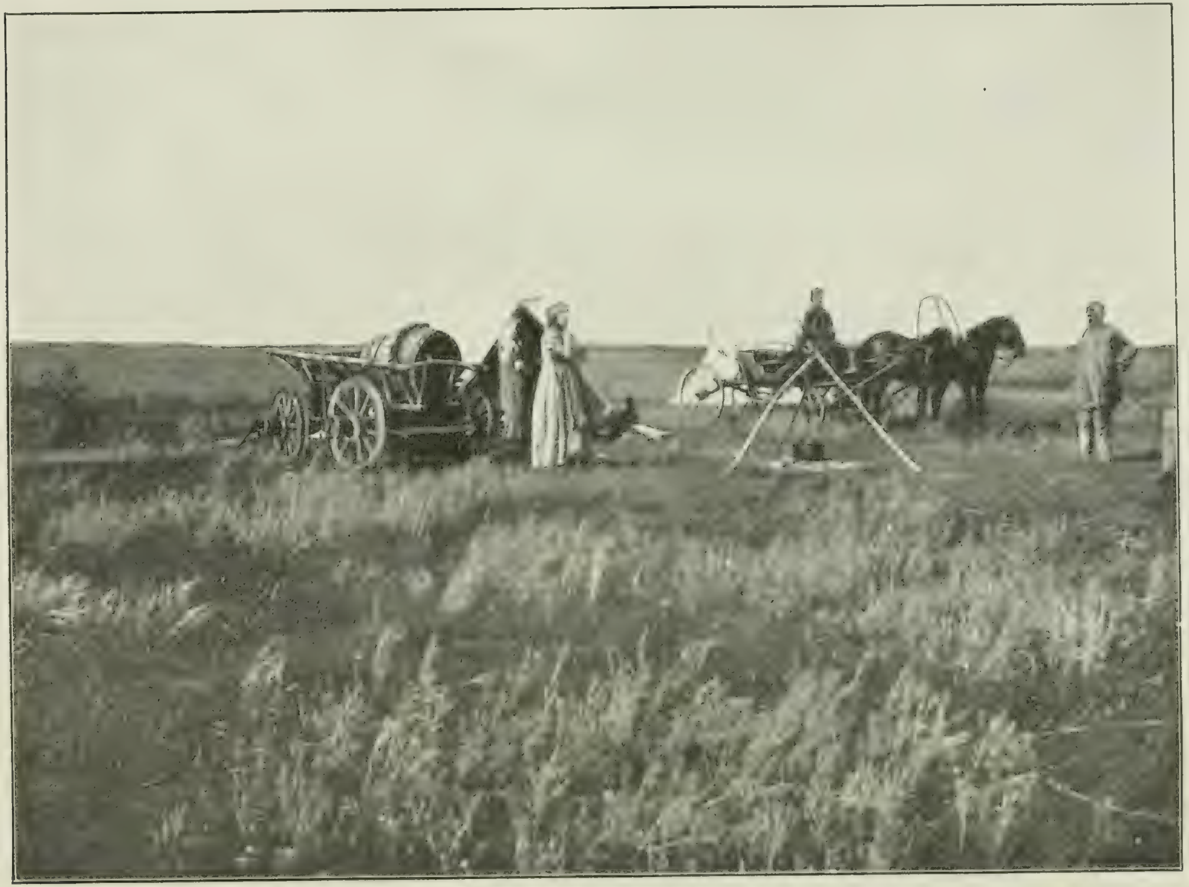
[1] These may be grown as winter wheats, however, as far north as southern Kansas.

PLATE VII.



CAMP OF KIRGHIZ HARVESTERS NEAR URALSK, ON THE SIBERIAN BORDER; A TWO-HORSE RUSSIAN VEHICLE FROM THE CITY IN VIEW.

drier the air the better. In east Russia the peasant farmers (Pl. VII) even go so far as to practice reaping only at certain hours in the hottest part of the day, claiming that the quality of the grain is made more perfect in that way.

EFFECTS OF LOCAL VARIATIONS IN SOIL AND CLIMATE.

All macaroni wheats are extremely sensitive to changes of soil and climate. This fact will account for certain peculiarities in the quality of the grain that have already been noticed by growers occasionally in this country. Samples are now and then received by this Department in which the grains are partially soft and white. These are from crops grown either under damper, cooler conditions, or in places where there is comparatively little nitrogen in the soil. The requisite conditions for a perfect grain are a *black prairie soil* and *short*, *hot*, *dry summers*. On the whole, changes of climate appear to have a greater effect than changes of soil, but if the soil becomes almost bereft of humus the grain shows the effect plainly by becoming more opaque and white, because of the preponderance of starch. If in this case the climate is at the same time arid, the grain remains rather hard, but simply because of its dryness. If the soil is black and rich and the climate too moist, there is considerable discoloration and black ends (mouchetés) may show themselves. Two or three good rains are sufficient to mature a crop. Otherwise, the drier and hotter the better, while a humid atmosphere can not be tolerated.

VARIETIES.

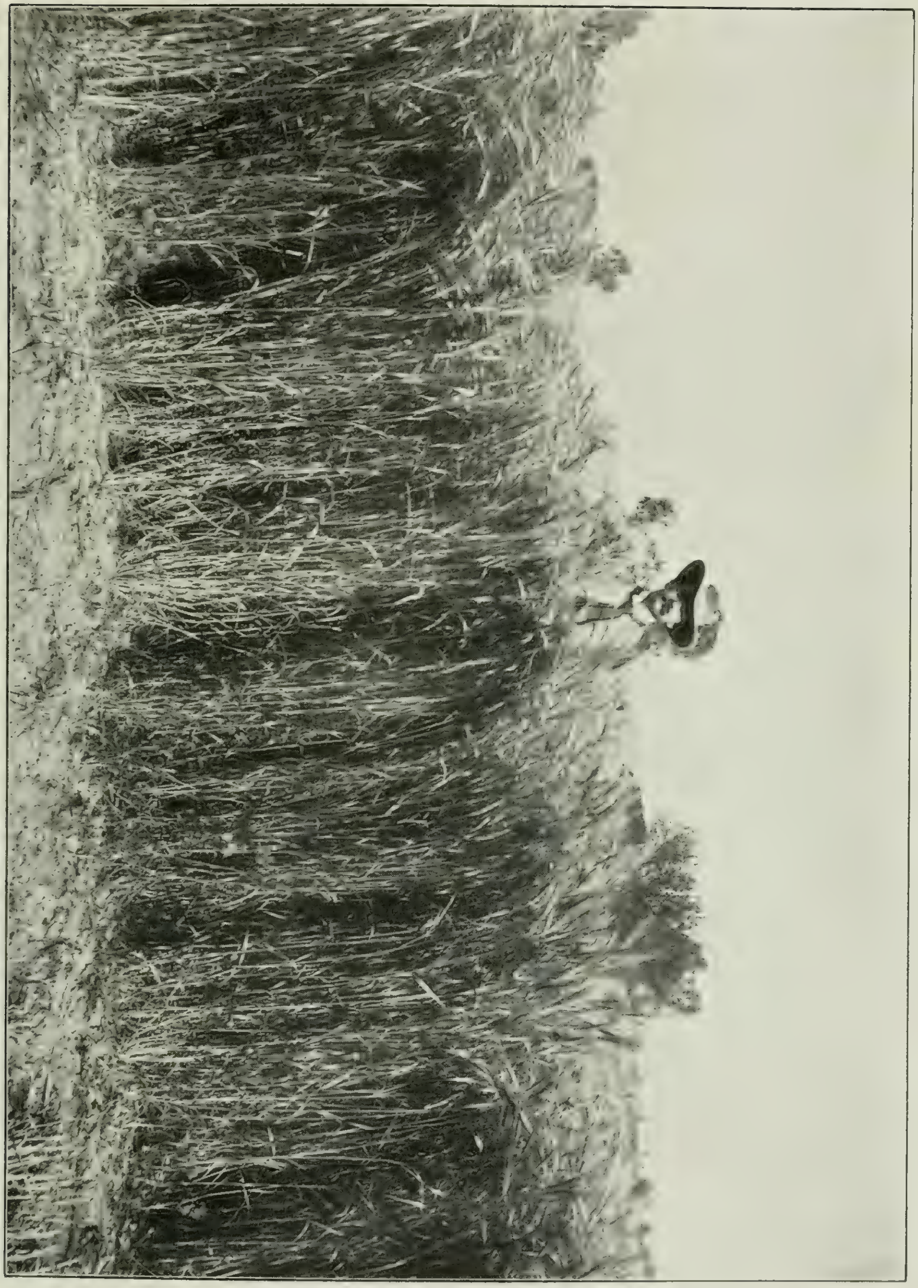
From 50 to 75 so-called varieties of durum or macaroni wheats have been described by different writers. If we include with these a number of others that have not been mentioned in print, there are probably a hundred or more varieties already known to be in use under distinct names. A very critical study would be necessary to determine how many of these are identical with each other. Durum wheats of nearly a hundred different descriptions are now under experiment by this Department, and many more will be added before the end of this year. Though the larger number of varieties are, in practical use, of minor importance, there are a few having well-marked characteristics, and which have attained a high reputation. As some of these varieties are likely to furnish the larger part of the entire macaroni wheat production of this country for a number of years at least, it will be advisable to describe them briefly here.

GHARNOVKA.

The variety which is the basis of a very large part of the macaroni wheat export from the Azov Sea region is the Gharnovka. Considerable confusion exists concerning the names of these Russian macaroni varieties, and even the statements of grain experts occasionally conflict with each other. But it is certain that the name Gharnovka is most generally applied to the usual variety grown throughout this region. The wheat itself has a medium long, square, dense, yellowish-white head, while the beards are dark and very long. The grain is quite large, light yellow in color, and rather translucent and vitreous. There are several different strains even of the Gharnovka recognized in the Don territory. Probably the best of these is the Yellow Gharnovka, which has a grain of a deeper yellow than the others. The best quality of Gharnovka seems to be grown in the district between Kerch and Berdiansk. A good quality is occasionally obtained also in the Eisk district just southeast of Rostov-on-Don. Both the Gharnovka and Yellow Gharnovka have recently been obtained and distributed by this Department. This wheat is admirably adapted to such districts as Kansas, Nebraska, Oklahoma, and eastern Colorado. It will probably prove to be one of the best durum wheats for the middle and southern Great Plains, as well as for New Mexico and Arizona. Gharnovka is being grown this season by the New Mexico Agricultural Experiment Station, and so far gives promise of excellent results. A photograph of the wheat in the field (Pl. VIII) is kindly furnished by Prof. J. J. Vernon .

ARNAUTKA.

The two terms by which Russian macaroni wheats are usually known outside of that country are Taganrog and Arnautka. The former term is entirely meaningless. It does not correctly designate a special variety at all, but may refer to any wheat in east or south Russia, even to wheats that are not of the durum group. Arnautka is properly the name of a special variety, but is also often applied in a too general way. It is apparently not grown to so great an extent as Gharnovka, but it is nevertheless one of the best varieties of south Russia. So far as the writer can determine, what is properly called Arnautka is a wheat having heads of a light red color, with a bluish bloom and very long reddish beards. The grains are very large and long, and when grown under favorable conditions are a clear yellow, extremely hard and vitreous. This and Gharnovka are the two varieties which have given Russia its reputation for macaroni wheats, although one or two other Russian sorts are probably even better than these for making that product. Arnautka is the name always most familiar to Americans in speaking of these wheats. It was one of the first durum wheats to be introduced into the United States. The first importation was made by this Department in 1864, but the possibility of its future use with us as a macaroni wheat was then never thought of, it seems. It was grown occasionally for many years afterwards, but meeting with much opposition its cultivation was finally abandoned. The



GHARNOVKA WHEAT AT THE NEW MEXICO EXPERIMENT STATION.

variety has, however, been imported occasionally for seed up to the present time. The writer has so far seen nothing but the grain of the variety now grown considerably by the farmers of North and South Dakota under the name Arnautka, and can not say whether it is the same as that above described or not. This variety is well adapted for cultivation in Kansas, Colorado, Oklahoma, and Texas.

KUBANKA.

This is a well-known and plainly distinguished variety (Pl. I, *1*) grown chiefly in east Russia, and from all standpoints is one of the two or three best Russian macaroni wheats. It has been twice imported by this Department in the last two years, and distributed chiefly to the State experiment stations. In districts where it is adapted its trial has already been followed by remarkable results, much beyond the expectations of the writer, who knew it to be the best wheat on the Siberian border. It is one of the most drought-resistant varieties known in east Russia, and produces a grain of excellent quality. It has medium or short heads, that are white with occasionally a slight bluish bloom, and have rather long beards. The grain is large, yellowish white, and very hard. The variety is much grown by the Kirghiz and Turghai people on the Siberian border (Pl. IX, fig. 1), where it is absolutely impossible to grow ordinary wheats of any kind because of the extreme drought, the rainfall being as low as 10 inches per annum. On being grown in the northern Great Plains it has uniformly given yields better than those of other wheats, and in the more arid portions has yielded 2 to 4 times as much. In the Dakotas it ripens in good time, and in Nebraska is much earlier than other wheats. At Arapahoe, Nebr., it matured in 76 days from seeding. It is constantly resistant to all diseases wherever tried in this country. This variety takes its name from the Kuban territory. It is cultivated throughout the entire Volga River region from Kazan to the Caspian Sea, and eastward into the Kirghiz Steppes and Turkestan. It is the most popular bread wheat of the lower Volga region (Pl. IX, fig. 2.) At Saratov and Tsaritsyn a very large amount of it is ground into bread flour, but is usually mixed with 10 to 20 per cent of red wheat in grinding. The flour is always yellow, and makes a yellowish bread with a rich brown crust. Kubanka is particularly adapted for our northern Great Plains as far south as Kansas, but might be grown as a winter wheat still farther south.

PERERODKA.

This is properly but a special strain of the variety Kubanka supposed to have been evolved through the influence of changes of soil and climate, particularly the former. Though considered in east Russia to be in general rather inferior to Kubanka, it has in certain respects given better results than the latter in this country. In North Dakota it yielded better, and in South Dakota the grain was discolored less than that of Kubanka. It yielded considerably more to the acre in North Dakota than the Fife and Blue Stem. The grain is darker colored originally than that of Kubanka; otherwise they are practically the same.

BELOTURKA.

The variety Beloturka is very similar to Kubanka, but differs from it in having a longer, narrower head, and longer grain which is not so thick. Like Kubanka it is also extremely drought resistant. It is grown throughout the Volga region, but especially in southeast Russia. The name means "White Turkish." It is well known to be very resistant to rust in all countries, but has been especially well tested in this regard in Australia. Its value in this respect has been conclusively shown in all experiments by this Department. Beloturka and Medeah are the two varieties particularly recommended for rust resistance in hot coast districts by the Australian Rust-in-wheat Conference of 1892. The bright yellow grain is of the very best quality. It is probable that if there were a better knowledge of varieties among the macaroni wheat dealers of France and Italy, it would be noted that this variety and Kubanka are really of better quality than the varieties Arnautka and Gharnovka, which have obtained their reputation partly by the mere association of being grown near Taganrog; and as before stated all the wheat, Gharnovka, Kubanka, or otherwise, goes to Mediterranean ports as simply Taganrog wheat. Beloturka is also adapted for growing in the northern Great Plains especially.

VELVET DON.

This variety, called Chernouska in Russia (Pl. I, *3*), has heads of medium length, rather thick, always with velvet chaff and long black beards. There are usually brown spots on the chaff throughout the length of the head. The grains are quite large, very hard, and darker in color than in the varieties just described. It is grown to a considerable extent in the Crimea and near Sarepta in the Volga River region. Mr. Nekludov, superintendent of the large Mikhalkov estate at Ambrocievka, Don territory, says that under the general term Arnovka (probably the same as Arnautka) are included Gharnovka, Yellow Gharnovka, and this variety. He also considers Yellow Gharnovka to be the best variety in that region, and Chernouska or Velvet Don to be the next best. (See fig. 2.) Velvet Don has been imported by the Department, and is now being grown by several of the State experiment stations. This variety is well adapted for growing in any portion of our semiarid districts, but may prove to be specially fitted for use as

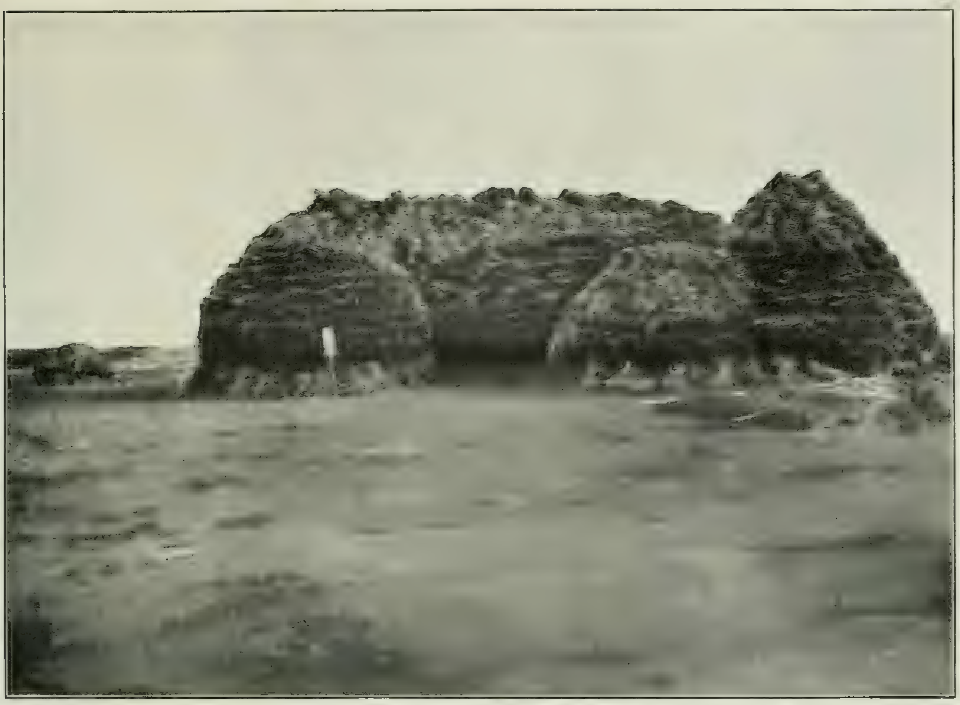


FIG. 1.—STACKS OF KUBANKA WHEAT NEAR URALSK, ON THE SIBERIAN BORDER.

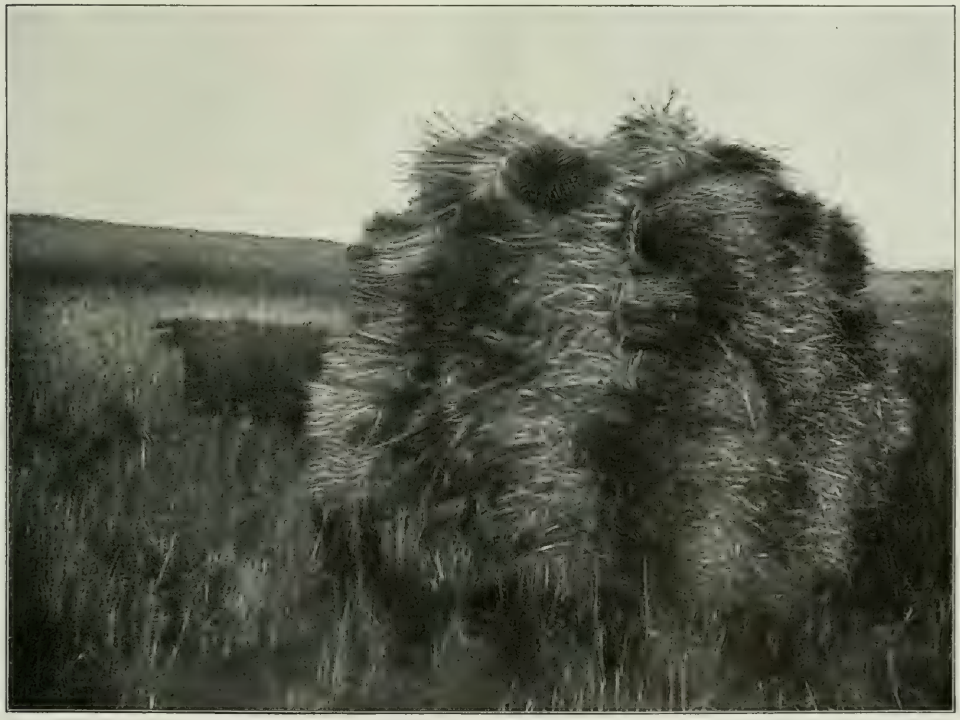


FIG. 2.—METHOD OF SHOCKING MACARONI WHEAT NEAR SAREPTA, IN THE VOLGA RIVER REGION.

a winter wheat in Texas. It is very drought-resistant and ought to be quite resistant to leaf rust.[1]

BLACK DON.

Black Don (Pl. I, *4*) is known as Chernokoloska in Russia, and is grown a great deal in the Don territory, as well as throughout the Volga region, and to some extent in the Crimea and in Siberia. The variety is characterized by heads of medium length with black chaff, having a bluish-white bloom and long black beards, and light yellow, very hard translucent grains of medium or large size. The appearance of the grains is similar to that of Gharnovka, though the quality is probably not quite so good. The best quality of this variety seems to be grown in the district near Sarepta, in the Volga River region. When grown from well-selected seed its appearance in the field is very striking, because of the black heads. This variety has also been imported by this Department and distributed in several of the States of the semi-arid districts. It is well adapted for any portion of these districts, but may be especially suitable for a winter variety in Texas.

FIG. 2.—Cleaning Velvet Don wheat on the estate of Mr. Mikhalkov, in Don Territory.

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[1] On the other hand, in unusually damp, cloudy seasons all these macaroni wheats are likely to be severely affected by the black stem rust. In the Don territory, near Taganrog, some fields were almost ruined by that rust in 1900, as observed by the writer.

SARUI-BUGDA.

A variety known by this Tartar name and which is apparently distinct but may be closely allied to Beloturka or Arnautka, is grown considerably in North Caucasus, near the Caspian Sea, but especially in Turkestan. It is probably one of the most drought-resistant wheats known anywhere, being the chief durum variety of the arid region of Turkestan. It no doubt also resists extremely the injurious effects of strongly alkaline soils. The grain is very large, yellowish white, extremely hard, vitreous, and translucent. Heads of the wheat as grown in Turkestan have not been seen by the writer, but from descriptions they are in every way similar to Beloturka, except a tinge of red in the chaff. So far as known to the writer, it has never been shipped in quantity for making macaroni, so that its value for that purpose is not known. It is of special value to us at present, because of its superior drought resistance, but may be found to be excellent for macaroni as well. The best quality of grain so far seen by the writer came from the Lenkoran district on the Caspian Sea.

In 1899 Prof. N. E. Hansen obtained for the Department a durum wheat numbered 1174, Section of Seed and Plant Introduction, which came originally from Turkestan, and which appears to be equivalent to Sarui-bugda, but which may prove to be distinct. A difficulty in studying it (1174) arises from the fact that it is badly mixed with another variety; but when grown in this country the part of the crop resulting, which is true durum, is very vigorous, extremely hardy, and of fine appearance in head and grain. It was distributed rather widely, and the results in semiarid districts have been uniformly good.[1] This and Sarui-bugda are admirably suited for growing in the driest portions of the Great Plains, where anything can be grown at all.

MEDEAH.

The variety Medeah (Pl. II, *2*) has of all wheats attained the greatest reputation for rust resistance.[2] It is mentioned oftener than any other in discussions of that subject, but it is especially recommended in Australia[3] and Cape Colony[4] as a result of investigations with rust in those countries. In the conclusions of the several rust-in-wheat conferences in Australia, this variety was recommended along with Beloturka as being the best for the hot coast districts. It has been much employed by William Farrer, a wheat expert of New South Wales, in hybridizing with other varieties in order to introduce the same quality of rust resistance into ordinary bread wheats. In experiments made by this Department it has been found to maintain consistently its reputation in this regard in this country also.[1] It is a well-known Algerian variety, having medium-sized brown or black heads, with a bluish bloom to the chaff, and black beards, and yellowish, hard grains. It is similar to Black Don in general appearance. Aside from its rust resistance, Medeah has a good reputation for drought resistance and yield in many countries. It is especially well adapted to our middle and southern great plains, particularly in Texas.

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[1] The selected durum portion of 1174 has been separated and numbered 1548 in the cereal investigations of the Department. The other portion, which is a bread wheat and is numbered 1550, may prove also to be of great value in further experiments on account of its earliness in ripening.

[2] Probably referring to orange leaf rust in nearly all cases, however. This point is difficult to determine, since there are so few cases of reported rust resistance in which it is stated definitely which rust is meant.

[3] See report of Australian Rust-in-Wheat Conference for 1892, p. 71; also various articles in Agricultural Gazette, New South Wales.

[4] See numerous short articles in Agricultural Journal of Cape Colony, and especially Vol. XV, pp. 229–235, August 17, 1899.

PELLISSIER.

This is a much-praised, selected variety, bred in Algeria. It seems at present to be one of the best of the Algerian varieties, and will probably be a valuable variety for our southern great plains. M. Henri Vagnon, at Kherba, Clos des Bras, Algeria, has grown El Safra, Nab-el-bel, and several of the other best varieties, along with Pellissier, in that part of Algeria, and as a result of his experiments highly recommends the latter.[2] Seed of these varieties was obtained by the Department from M. Vagnon in 1896, and the varieties have been grown in Kansas in experiments to determine rust resistance. Pellissier not only proved to be quite rust resistant, but appeared to be a good, hardy wheat in other respects.

CANDEAL.

This variety is the principal durum wheat of Argentina and Chile, having been introduced there originally from Spain. It has heads of medium size, with white smooth chaff and rather long white beards. The grains are rather large and light yellow. Practically all the wheat furnished to France and Italy from South America for macaroni, which has come to be considerable in recent years, is of this variety. It has been tested for rust resistance in field experiments made by this Department and found to be very good in that respect. Its drought resistance and quality of grain in this country is yet uncertain. It is adapted for cultivation in our middle and southern Great Plains region.

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[1] Cereal rusts of the United States, Bul. 16, Div. Veg. Phys. and Path., pp. 23–40, September 27, 1899.

[2] See "Culture Rationnelle des Céréales en Algérie," Jour. d'Agric. Pratique, 59^{e}, Tome I, pp. 494–498, 1895. In this report M. Vagnon names Pellissier, El Safra, and Volo as the best three in his experiments, placing Pellissier as first.

NICARAGUA.

Until recently probably no one of the durum wheats has attracted so much attention in this country as Nicaragua, and it is practically the only wheat of this group yet known in the southern United States. Its origin is not known to a certainty, though the name would indicate that it came from Nicaragua, and the wheat almost entirely grown in Nicaragua is of the same group as this variety. The real Nicaragua wheat has recently been received by the Department from Mr. I. A. Manning, United States consular agent at Matagalpa, Nicaragua, and its appearance is in all respects like this variety, so far as the grain is concerned. From various reports it appears that Nicaragua has been grown in Texas nearly twenty-five years.

Mr. James J. M. Smith, whose letters have already been quoted, states in his letter of May 29, 1898, that—

> In 1878 I found this wheat growing abundantly in Burnet, Williamson, Bell, Travis, Lampasas, Llano, and San Saba counties. I learn also that it was raised extensively all over this section of Texas.

Almost invariably it has given excellent yields, far above that of any other wheat, including the popular Mediterranean. It has apparently made average yields of from 20 to 30 bushels per acre, and quite often yields 40 to 50 bushels per acre. Its cultivation has always been chiefly in Texas, but it is grown occasionally also in South Carolina, Georgia, Arkansas, Louisiana, and other Southern States. It first became popular almost wholly on account of its rust resistance, but has since been found to be excellent for late fall pasturage.

Nicaragua wheat has rather long, narrow heads, with white or yellowish-white chaff and rather long beards, and a large, deep yellow, hard grain, when grown under favorable conditions. When sown in the autumn, as it often is in central and northern Texas, it makes a rank, vigorous growth and furnishes abundant winter pasturage. It is said to reach a height of 5 or more feet.

This variety to give best results in quality of grain should be grown farther west in Texas than it is now grown. As grown in the region from Wichita Falls and Abilene it ought to be of excellent quality for macaroni.

WILD GOOSE.

This variety is grown to a considerable extent in North and South Dakota, but on a much larger scale in Canada. It is related that a hunter found a few grains of wheat in the crop of a wild goose that he had killed, the grains were planted and grew, and the present variety has its origin in these few grains, and takes its name from the incident. Even if this story is true, the original grains must of course have been obtained by the bird from some farm in the Northwest, and as the Russian farmers of the Northwest have occasionally imported seed of durum wheats from Russia for many years, it is very probable that this variety is equivalent to one of the South Russian macaroni varieties. This and the preceding are the only macaroni wheats that have so far become pretty well established in this country.

Wild Goose has a white chaff, heads somewhat similar to Kubanka, and rather long beards. The heads are shorter and proportionally thicker than those of Nicaragua. The grains are quite large, light yellow in color, and very hard and translucent in the best grades of the wheat. A considerable amount of this variety has already been exported from Canada to France and Italy for making macaroni, and is reported to be in some instances equal to the Taganrog wheat for that purpose; and yet the wheat as grown in Canada is probably inferior to wheat of the same variety as grown in the Dakotas.

MISSOGEN.

Almost the entire wheat production of Greece is from the durum group. Bread there is commonly made from these wheats. There are a number of important well-known varieties grown, such as Missogen, Atalanti, Volo, etc. Missogen (Pl. II, *3*) is one of the best and is fairly representative. It has a medium or short head, rather thick and flattened, and with white, or reddish-white, chaff and beards of medium length. The grains are quite large, yellow or light brown, and very hard. In experiments of this Department it has proved to be extremely rust resistant with respect to orange leaf rust, and appears to be generally rather hardy.

POLISH.

This wheat, which belongs to a group entirely distinct from the true durum wheats, is already referred to and described on page 11. It may also be used in making various edible pastes, and possesses besides several other valuable qualities. It is very resistant to drought and leaf rust, and never was known by the writer to be affected with bunt or smut. Its yield in semiarid districts compared with other sorts is always good. As already mentioned, this wheat in 1891 yielded 24 bushels per acre without irrigation at Garden City, Kans., some distance west of the one hundredth meridian. Polish wheat was introduced from south Russia two years ago by this Department, and on being tried at several stations has yielded well in semiarid localities. It is adapted for growing in any part of the semiarid Great Plains.

WINTER VARIETIES.

Macaroni wheats are as a rule to be considered as spring varieties. Nicaragua, however, is very often sown in the autumn in Texas, and is said to give much better results when sown in that season. Other sorts when taken below the thirty-fifth parallel could no doubt also be transformed into good winter varieties by gradually increasing the earliness of spring sowing until they are practically sown in autumn. The wheat is thereby not only made more vigorous by its autumn root growth, but is also likely to yield more and furnish an abundant supply of early winter pasturage; for these wheats always make a vigorous growth at once after they come up.

EXPERIMENTAL COMPARISON OF VARIETIES.

As already noted, nearly all these macaroni varieties have been under experiment by this Department more or less at different times, testing their resistance to rust and drought, and in some cases their yields. Chemical analyses have also been made of many of them by courtesy of the Bureau of Chemistry of this Department and the results furnished to this Bureau for publication. Certain data from all these sources are here arranged in tabular form, for the most important varieties of macaroni wheat, as follows:

TABLE V.—*A résumé of the chief characteristics of the principal macaroni wheats as known at present.*

Name of variety.	Where grown.	Winter or spring.	Character of young plant.		Rust resistance (leaf rust).	Character of the head.			Character of the grain.					
			Color.	Manner of growth.		Form.	Chaff.	Beard.	Size.	Color.	Albuminoids.	Starch	Moist gluten.	Dry gluten.
Arnautka	Russia	Spring	Light green	Erect	(*a*)	Narrow	Reddish	Reddish	Large	Yellowish	*b*16.13 *c*14.00	....	*b*33.11 *c*37.70	*b*13.04 *c*13.55
Do	North Dakota.	do	do	do					do	Clear yellow	*d*15.19	(*d*)	35.35	14.10
Atalanti	Greece	Spring or winter.	Purplish	Narrow leaves.	(*a*)				do		14.38		31.72	11.65
Beloturka	Siberia	Spring	Light green	Erect		Narrow	White	White	do	Yellowish	14.19		34.61	12.24
Black Don	Russia	do	Very light green.	do	85	Average	Black	Black	do	Light yellow.	*e*15.75 *f*14.19	.... *f*59.74	*e*41.00 *f*33.58	*e*14.68 *f*13.02
Candeal	Argentina	Winter	Light green	do		Medium	White	White	do	Yellowish	11.69	58.22	24.34	9.01
Farrer's Durum	Australia	Spring or winter.	do	Erect, very narrow leaves.	(*a*)	Narrow			Medium	do	14.77		41.44	14.49
Gharnovka	Russia	Spring	do	Erect	89	Average	Yellowish white.	Dark	Large	Light yellow.	*g*14.19 15.38 *h*12.21	*g*59.63 .... *h*61.05	*g*36.61 27.30 *h*34.41	*g*13.68 13.90 *h*12.58
Kubanka	do	do	Very light green.	do	(*a*)	Short	White	White	do	Yellowish	*e*16.63 *i*12.88 *j*13.88	.... *i*62.48 *j*52.13	*e*37.79 *i*36.61 *j*34.40	*e*13.63 *i*13.63 *j*12.25
Medeah	New South Wales.	Winter	Light green	do		Average	Black	Black	do	do				
Missogen	Greece	Spring or winter.		do	(*a*)	Thick	Red	Reddish	do	Light yellow.	16.63		37.92	14.22
Nicaragua	Texas	Winter	Light green	do		Narrow	White	White	Medium	Yellow	11.88	55.31	27.79	10.28
Pellissier	Algeria	do		do		Average or large.			Large	Light yellow.	11.00	56.04	24.02	9.39
Perrodka	Russia	Spring	Very light green.	do		Average or short.	White	White			16.00	52.13	39.80	14.39
Polish	do	do	Light green	do	(*a*)	Very large	do	White, disappear.	Very long.	Yellowish	17.69	52.59	36.81	13.55
Sarui-bugda	do	do	do	do		Average	do	White	Large	do				
Velvet Don	do	do	do	do	96	Thick	Velvet, reddish.	Black	do	Yellowish brown.	*e*15.91 *f*14.41	.... *f*59.70	*e*38.22 *f*34.72	*e*11.10 *f*13.21
Volo	Greece	Spring or winter.	do	do		do	Brown	Reddish	do	Amber yellow.	12.06		28.00	10.22
Wild Goose	Canada	Spring	do	do	(*a*)	Average	White	White	do	Yellowish	13.48		32.56	13.09
Yellow Gharnovka	Russia	do	do	do					do	Clear yellow	14.00	60.00	35.54	13.15

a Almost rust free. The figures give actual per cent of resistance.
b Sample from Kharkov.
c Sample from Poltava.
d Carbohydrates, 67.74; protein, 16.50.
e Sample from Kursk.
f Sample from Don Territory.
g Sample from Taganrog.
h Sample from Ambrocievka.
i Sample from Uralsk.
j Sample from Orenburg.

As will be seen by the table, macaroni wheats almost always are light green in color in the first stage of their growth, while ordinary wheats are a darker green. There is also rapid growth at this stage; the leaves are usually large and the plants grow erect, thus affording the abundant pasturage for which fall-sown varieties are noted. As to chemical composition, nearly all varieties here presented are uniformly high in gluten content and the percentage of albuminoids. Ordinary bread wheats are considered to have an unusual gluten content if it reaches 11 or 12 per cent dry gluten, but it is not especially unusual for these wheats to have 13 and 14 per cent. On the whole, Russian varieties have invariably a higher per cent of gluten and protein than those of other countries. In confirmation of the expectation of the writer, it is seen that the Arnautka from North Dakota compares well with the best varieties direct from Russia in protein and gluten content. It is, however, a Russian variety originally, and when grown in North Dakota, simply finds very similar conditions to what it has previously been used to. The superiority of Russian varieties, already shown by their greater demand as well as their higher protein content, and also the excellent quality of durum wheat, when grown on our Great Plains, is almost certainly due to the unusual humus content of the soils of the Russian and American regions, respectively, which has already been discussed. The proper climate is a feature probably of greater importance, but a considerable amount of soil humus is absolutely essential. In harmony with this thought it is to be expected that Algerian or Argentine varieties will improve on being grown on our Great Plains, while Russian varieties will probably deteriorate when grown in Arizona or New Mexico. But Russian sorts grown in the region from North Dakota to west Kansas, or possibly to the Texas Panhandle, will be the very best.

There seems to be something more than the simple amount of gluten that gives macaroni wheats a superiority over bread wheats for making macaroni, since often bread wheats having the same gluten content do not apparently make as good macaroni. Nevertheless, gluten content is evidently important, and, besides, the unusual protein content of such wheats is of great importance from the standpoint of nutrition.

RUSSO-MEDITERRANEAN TRAFFIC IN MACARONI WHEAT.

In making up statistics of wheat production and export separate figures are never given for durum wheats, even in Russia, where such wheats are so important. It is therefore only possible to obtain an approximate idea of the export of these wheats from Russia to the western Mediterranean region. It is known to be quite extensive, however, in proportion to the amount of other wheats exported from that country. The Section of Foreign Markets of this Department has kindly furnished data giving the entire wheat export of Russia

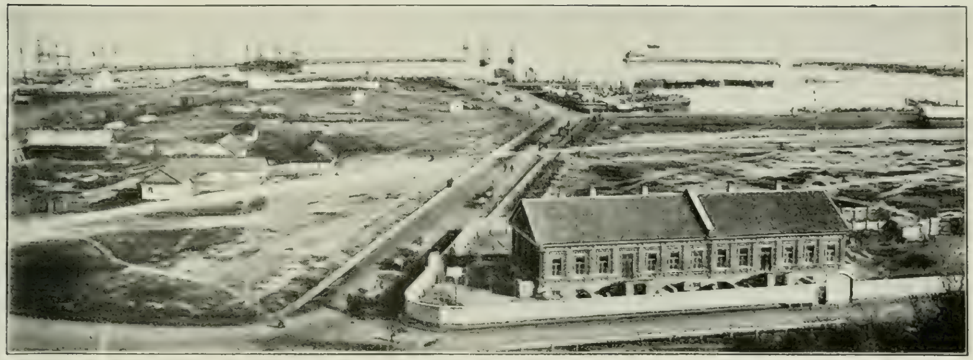

FIG. 1.—PORT OF TAGANROG, RUSSIA, THE LARGEST PORT FOR THE EXPORT OF MACARONI WHEAT IN THE WORLD.

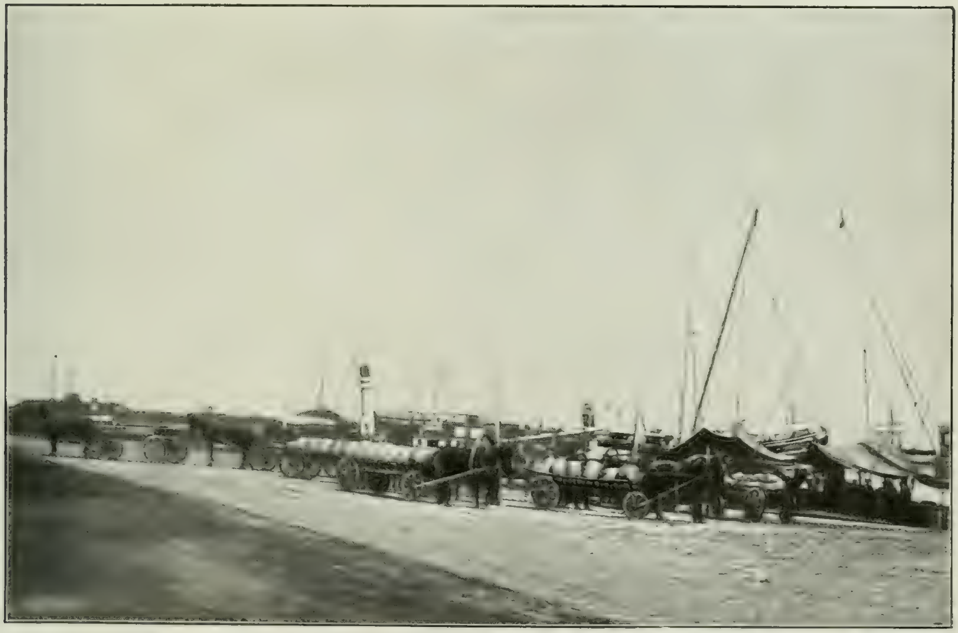

FIG. 2.—LOADING GHARNOVKA (MACARONI) WHEAT ONTO THE STEAMER IN BULK AT TAGANROG, TO BE SHIPPED TO MEDITERRANEAN PORTS.

for the years 1894–1898, inclusive, and her export to France and Italy for the same period. The entire export averages 126,677,079 bushels. The average export to France is 19,892,517 bushels (including spelt and maslin[1]), and the export to Italy averages 21,204,469 bushels. It is known that a considerable quantity of the export to Italy is soft wheat. In other data giving imports into France and Italy from Russia, also furnished by this section, it is definitely stated that in 1899 6,274,129 bushels of the import into Italy was soft wheat; that is, considerably more than one-third of the entire amount for that year, which was 15,400,153 bushels. It is pretty certain that the proportion of soft wheat shipped to France from Russia is much less, probably not more than one-fifth. The entire wheat export to both France and Italy is 41,096,986 bushels. It is probable that the soft wheat, spelt, maslin, etc., would altogether make up no more than one-third of this amount. To be safe in statements, however, the proportion of macaroni wheat shipped from Russia to these two countries may best be given, not as two-thirds of the entire amount, but as about 20,000,000 bushels. But certainly not more than four-fifths of the Russian Mediterranean export of this wheat goes to France and Italy. Adding, therefore, 5,000,000 more for the other countries on the Mediterranean we have what is surely a conservative estimate of 25,000,000 bushels as representing Russian export of this class of wheat into the Mediterranean region. The Russian trade in these wheats is far greater than Americans realize. In fact, many do not realize that there is such a trade at all. The writer is rather confident that the entire annual Russian export of durum wheat to all countries does not fall far short of 40,000,000 bushels. It must be remembered, too, that in the markets where this wheat goes no other wheat can be substituted. To compete with Russia in these markets we must therefore raise macaroni wheats. If we should succeed in securing only half the market it would mean an addition of 20,000,000 bushels to our export trade. It should be noted that international freight rates on grain exported from this country appear to be about the same as for Russia and the oriental countries.

The steamers engaged in the Russian export trade with this wheat belong to several different lines, the best known of which is probably the Russian Society of Commerce and Navigation. This is the most important steamship line in south Russia, has excellent harbors, and touches at all points on the Black and Azov seas. The principal points from which durum wheats are shipped are Taganrog (Pl. X, figs. 1 and 2) and Berdiansk, but large quantities are shipped also from Rostov-on-Don, Novorossisk, Theodosia, Kerch, Mariopol, and Nikolaev. Four or five trunk lines of railway (at least two of which are doubled tracked) bring most of the wheat that is grown at a distance to these points. Much the larger part of this wheat from a distance comes from the region about Uralsk and Orenburg. (Pl. XI, fig. 1.) At Taganrog and Berdiansk a large portion of the wheat shipped is macaroni wheat. A great deal of it is grown in the surrounding region. The wheat begins to arrive in greatest quantities in September. (Pl. XI, fig. 2.)

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[1] Maslin is a mixture of several grains, as rye, barley, and wheat.

SUMMARY.

(1) Macaroni or durum wheats have been occasionally grown in this country for many years, but the absence of a known market has heretofore prevented their extensive cultivation.

(2) In connection with its seed and plant introduction work the Department has been making special effort during the past three years to stimulate an interest in American-grown wheat of this class. As a result of this movement, and with the aid of private parties interested, the following progress has already been made:

(*a*) All macaroni wheat of good quality that will be produced this present season (which will probably amount to over 75,000 bushels) is now practically contracted for at a good price.

(*b*) A majority of our own macaroni factories desire to use semolina of durum wheats grown in the United States, and from some of them there is now an urgent demand for it, but it can not be obtained.

(*c*) Samples of our macaroni wheats sent to French manufacturers of semolina have been tested and reported to be as good as wheat from Taganrog, Russia, though it is known that a much better wheat is now grown in North and South Dakota than the samples that were sent.

(*d*) Semolina manufacturers in France and Italy have only recently discovered the excellent quality of our macaroni wheat, and now they are demanding large quantities just as soon as it can be furnished. Six or eight million bushels, if we could furnish it, would no doubt now find immediate sale at Marseilles and in Italy.

(3) In connection with these facts it may be noted that since March 1, 1901, three and one-third million bushels of Wild Goose wheat were shipped from Canada to Marseilles, and yet the Canadian wheat is somewhat inferior, as a rule, to wheat of the same class grown in North and South Dakota.

(4) A careful investigation of the conditions of soil and climate in east and south Russia in comparison with those of our Great Plains shows an interesting and remarkable similarity between the two regions. As the very best macaroni wheat is produced in large quantities in this Russian region one naturally infers that the cultivation of such wheat in the Great Plains would be attended with good results.

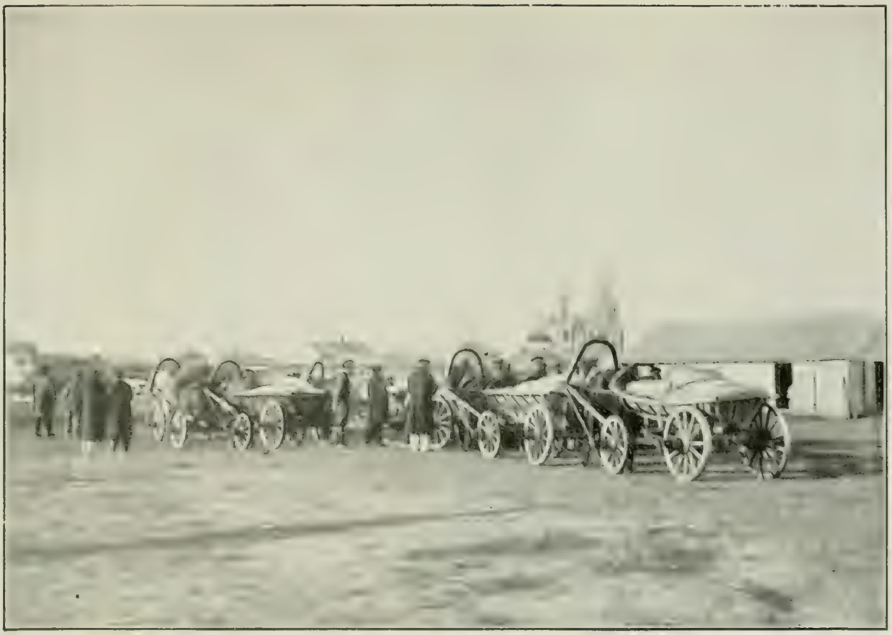

FIG. 1.—KUBANKA WHEAT BROUGHT TO MARKET BY THE KIRGHIZ FARMERS, AT URALSK, ON THE SIBERIAN BORDER.

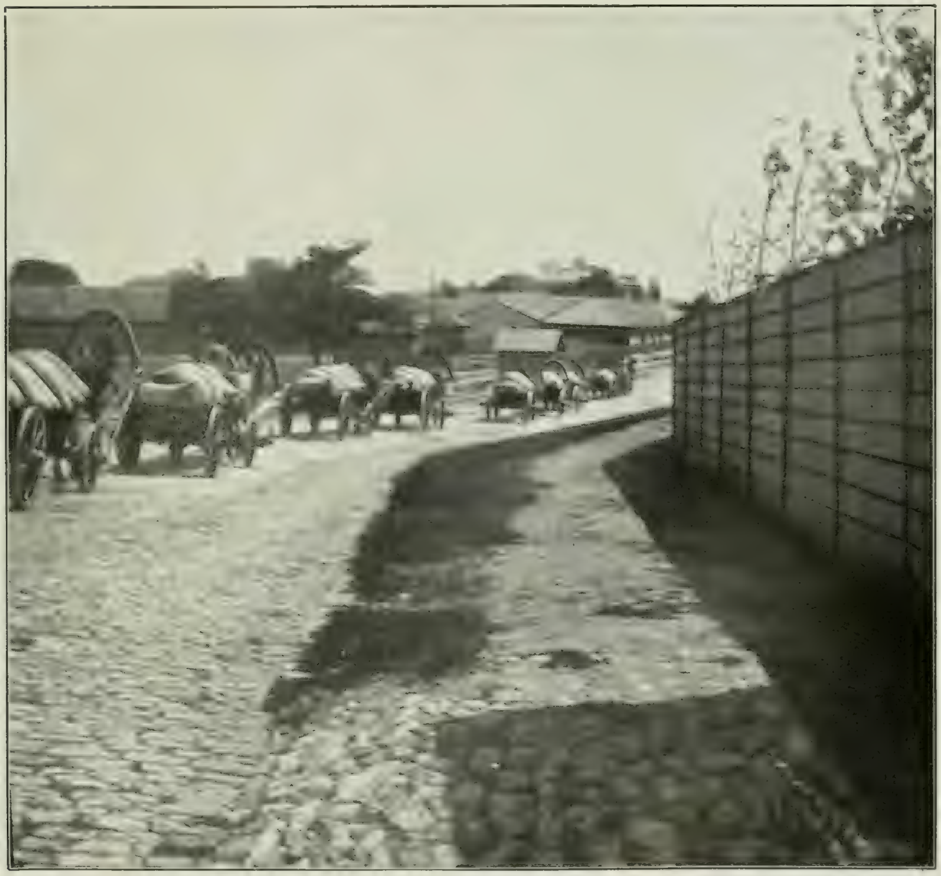

FIG. 2.—CARTING MACARONI WHEAT TO THE WHARVES AT TAGANROG, TO BE SHIPPED TO MEDITERRANEAN PORTS.

(5) The results of adaptation experiments made by this Department in cooperation with State experiment stations, as well as trials made by private parties, have strongly confirmed the conclusion drawn from a study of the soil and climatic conditions. The principal facts shown by these experiments are as follows:

(*a*) Macaroni wheats are extremely resistant to heat and drought.

(*b*) They are also very resistant to the attacks of leaf rust, smuts, and other parasites.

(*c*) They give the best results in the Great Plains near the one hundredth meridian.

(*d*) In many places west of the one hundredth meridian where wheat growing is now practically impossible because of drought macaroni wheats will yield ordinarily 12 to 20 bushels per acre.

(*e*) In semiarid districts macaroni wheats will yield an average of about one-third more per acre than the standard wheats usually grown there.

(6) Macaroni manufacturers do not, as a rule, grind their own wheat, but must be furnished with semolina by millers of that product.

(7) There is now a distinct demand for one or more enterprising millers in this country to arrange for specializing in the manufacture of semolina from durum wheats for our macaroni factories.

(8) Macaroni wheats can be readily ground at our ordinary flour mills by a slight rearrangement of machinery, using more moisture, and with a proper understanding on the part of the miller of the nature of the product to be furnished to the factories. The miller or manufacturer of semolina should stand in the same relation to the macaroni manufacturer that the miller of bread flour does to the baker.

(9) Nearly all our own macaroni factories are at present using flour made either from Kansas hard winter wheat or from the hard spring wheats.

(10) The superior value of durum wheats for making macaroni lies chiefly in the quantity and quality of their gluten, but possibly also in the amount and nature of certain other constituents.

(11) Macaroni when well made from our hardest bread wheats is sometimes difficult to distinguish from macaroni made from durum wheats. Almost always a difference exists, however, in favor of the product from durum wheat. The latter is usually (a) more yellowish in color, (b) more vitreous in fracture, (c) preserves its form longer in boiling, and (d) is more elastic and not sticky when served.

(12) Though macaroni wheats are usually considered to be adapted only for making macaroni, it is an idea entirely erroneous that they do not make good bread. But in grinding for bread 10 to 20 per cent of red wheat might, often with advantage, be mixed with them.

(13) In all instances in this country within the writer's knowledge

where these wheats have been used for bread the parties so using them have preferred the bread above all other kinds.

(14) The most popular bread flour in the Volga River region of Russia is made from Kubanka, a macaroni wheat.

(15) The French people, who are the greatest bread eaters in the world, prefer always a mixture of durum wheat in making their bread flour.

(16) Bread made from macaroni wheats is richer to the taste and remains fresh much longer than bread made from other wheat.

(17) Macaroni wheats furnish an excellent quality of grits for breakfast foods.

(18) In the cultivation of macaroni wheats all means possible should be employed for the conservation of moisture if they are to be grown where the rainfall is very small. They are drought resistant, but they must have the aid of proper cultivation.

(19) In all places north of the thirty-eighth parallel they should be sown in the spring, and the plowing may be done the previous summer. South of this parallel they should be sown in late autumn.

(20) In the South when sown in the autumn these wheats furnish excellent winter pasturage, usually, too, without greatly diminishing the following crop of grain.

(21) The best macaroni wheats in all respects are of Russian origin. The results of chemical analyses show that Russian varieties contain nearly 50 per cent more gluten than varieties from other foreign countries. Moreover, they are, as a rule, best adapted to the conditions of our semiarid districts.

(22) The best of the Russian varieties, and those which are best adapted to our middle and northern Great Plains, are the following: Kubanka (or Pererodka), Yellow Gharnovka, Gharnovka, Black Don, Beloturka, Sarui-bugda, Velvet Don.

(23) Some of the best varieties from other countries and adapted to the region of this country south of the thirty-fifth parallel are as follows: Nicaragua, Missogen, Medeah, Volo, Pellissier, Atalanti, Candeal, El Safra.

(24) The Russian export of macaroni wheats to the Mediterranean region is probably at least 25,000,000 bushels annually, and is an indication of the export trade with these wheats that we might secure (in part, at least) if we would grow them; for international freight rates are about the same for us to the Mediterranean region as for Russia.

O

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN No. 4.

B. T. GALLOWAY, Chief of Bureau.

RANGE IMPROVEMENT IN ARIZONA.

(COOPERATIVE EXPERIMENTS WITH THE ARIZONA EXPERIMENT STATION.)

BY

DAVID GRIFFITHS,

EXPERT, IN CHARGE OF FIELD MANAGEMENT,
GRASS AND FORAGE PLANT INVESTIGATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., September 6, 1901.

Sir: I have the honor to transmit herewith the manuscript of a paper on "Range Improvement in Arizona," by Dr. David Griffiths, expert in charge of field management in the Office of the Agrostologist, and respectfully recommend its publication as Bulletin No. 4 of this Bureau.

Respectfully,

B. T. Galloway, *Chief.*

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

This paper of Dr. Griffiths is the first report on experiments with grasses and forage plants conducted by the Department of Agriculture through this office in cooperation with the Agricultural Experiment Station of Arizona, located at Tucson. The report contains an outline of the experiments undertaken on the tract of public land set aside by the President of the United States for the use of the Secretary of Agriculture in this work. The existing conditions and the present character of the forage supply on the ranges is fully described. The urgent needs of the stockmen for better range conditions are clearly set forth. The publication of this report now will be most timely, as it brings before the public questions of the greatest importance to one of the largest interests of this country—the raising of live stock. While there are many forage problems of great importance which are now being worked out through this Office, there is none, we believe, of greater importance or more general interest than that of range improvement. The free-range system has led to the ruthless destruction of the native grasses which once covered the magnificent pasture lands of the West, and the time has now come when active measures must be adopted to remedy the evils that have resulted from overstocking and mismanagement. It is evident that laws for the proper control and preservation of the ranges are not only essential to the stock interests, but also to the general welfare of the country. The matter is of as much importance to the irrigation farmer as to the cattle man, for the gullying of river channels during recent years, and the cutting of deep gorges in every slight depression, destroying the tillable lands, are directly traceable to the influence of close grazing.

Prof. R. H. Forbes, director of the Arizona Agricultural Experiment Station, in an exceedingly valuable and interesting paper on the subject of "The open range and the irrigation farmer," read at the meeting of the American Association for the Advancement of Science held in Denver the present season, and which was published in The Forester, made the following most suggestive notes in relation to range improvement, which we venture to quote here:

> The objects of range study are, in the first place, to demonstrate economic methods for the improvement and reclamation of the great areas of devastated, worn-out grazing lands of the semiarid regions, and, finally, to suggest such administration of the country thus reclaimed, or the yearly decreasing areas of

yet unruined ranges, that the interests of all concerned—the stockman, the irrigation farmer, and the possible investor in the storage propositions of the future—may be brought into harmony with each other as well as be individually bettered.

* * * * * * *

In view of the difficulties and failure which have been encountered in this direction [range improvement] and in view of the successful operations of the forest-reserve system, it seems to me that we can turn with some hope of success to the idea of range reservation in Arizona and New Mexico. The Government is there yet in control of great unbroken tracts of its public lands, and those Territories afford a most favorable opportunity for the institution of the experiment on a large and convincing scale.

* * * * * * *

The carrying out of such a plan by impartial and authoritative means, including provisions for a proper economic and scientific study of the problems involved, ought in time to vastly improve the range for the benefit of the stockman, and also to render the operations of the irrigation farmer and of the storage-reservoir promoter much more certain of returns.

F. LAMSON-SCRIBNER,
Agrostologist.

OFFICE OF THE AGROSTOLOGIST,
Washington, D. C., September 6, 1901.

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RANGE IMPROVEMENT IN ARIZONA.

By David Griffiths,
Expert, in charge of Field Management.

INTRODUCTION.

On all the Western stock ranges which the writer has visited there have existed many small areas in cultivated fields, unused pastures, fenced railroad rights of way, and similar situations which are in their virgin state or have so far recovered from overstocking as to bear testimony to the original productivity of the soil. Things are far different in large areas of southern Arizona. Here unused pastures are very rare, cultivated fields are fewer in number, and the destruction is so complete that in many localities even the railroad right of way has recovered but little in three or four years' time. On the river bottoms a few indications of luxuriant growths of grass are found, but in nearly every case, even in such favored localities, there is little aside from this evidence, the actual original conditions being very much modified. It would be but fair to state, however, that the season in which the region was first visited was an unfavorable one, being at the close of an exceedingly long dry period, when even evidence of forage was scanty.

Many ranchers, farmers, and prospectors who have lived in the country a long time have given much information relative to former conditions, some certainly reliable and some doubtless extravagant, as is apt to be the case in such matters. From the evidence given by every old settler no conclusion could be reached other than that of misuse of the range country and that the destruction was greater than in the more favored ranges of the Northwest. How the destruction of the range could be so nearly complete is somewhat beyond the conception of those not familiar with the character of the precipitation, configuration of the land, composition of the soils, and the habits of the forage plants of the region. With the exception of the annuals the grasses are nearly all known as "bunch grasses," a designation which indicates that they are not turf formers. Even the blue grama (*Bouteloua oligostachya*), which forms such handsome and persistent sod over vast areas on the ranges of the Northwest, grows here in bunches. This prevailing characteristic, together with the susceptibility of the surface soil to injury by the trampling of cattle, probably accounts in a large measure for the extent of the denudation of the range. During a season of rain the surface of the ground is badly cut by the cattle that tramp over it. After the February rains the depth of footprints in an average mesa region is one-half an inch to 4 inches, the deeper ones being in the lower moister regions, which are best suited to the growth of vegetation. It will be readily seen that a herd of cattle do immense injury to the surface of the ground by traveling over it during a season of rain. Regions which have survived close pasturage are very liable to be destroyed or greatly injured in this way. During the dry seasons the injury from trampling is nearly if not quite as great. Having no turf of leaves and no protection of shallow roots, the surface soil is easily cut and reduced to dust by animals moving over it in search of food and water.

FORMER CONDITIONS.

As an accurate knowledge of the conditions which once prevailed throughout these valleys and foothills was very essential to a proper and intelligent inauguration of range-improvement experiments, it was thought that the best plan would be an effort to restore the condition which once prevailed, for any extended attempts at cultural operations appeared entirely useless. It was thought that the greatest benefit to the range would be derived from rest, accompanied by reseeding with native forage plants. Accurate knowledge of previous conditions was therefore very essential. In order to obtain this information a circular letter, accompanied by a series of questions, was prepared by the writer, who was at that time botanist of the Arizona Experiment Station, and distributed to a selected list of correspondents. The letter and questions, reproduced below, are self-explanatory and indicate clearly the purposes of the inquiry. The answers returned agree almost perfectly and point to but one conclusion, namely, that the public ranges of the region were at one time comparatively productive and that their present condition has been brought about by overstocking.

CIRCULAR LETTER AND QUESTIONS.

MY DEAR SIR: The Arizona Experiment Station, in cooperation with the United States Department of Agriculture, is undertaking some experiments with a view of ascertaining the best methods of improving the native ranges of Arizona. Already the Department of the Interior, at the request of the Hon. James Wilson, Secretary of Agriculture, has reserved from entry for our use a tract of land in the vicinity of Tucson, and a suitable portion of this has been fenced. We are, therefore, practically ready to begin operations along lines suggested by the best experience of the officers of this station, as well as of the field agents and officers of the Division of Agrostology, United States Department of Agriculture. It is hoped and expected that this work will result in profit to the ranchers and stockmen of the Territory, and what results in profit to them results in profit to every citizen.

In order to undertake this work intelligently it is necessary to ascertain as accurately as possible the original condition of the range prior to its depletion by overstocking and prior to the excessive droughts of a few years ago, for it is by restoring the range to its original condition that we may hope to receive benefit

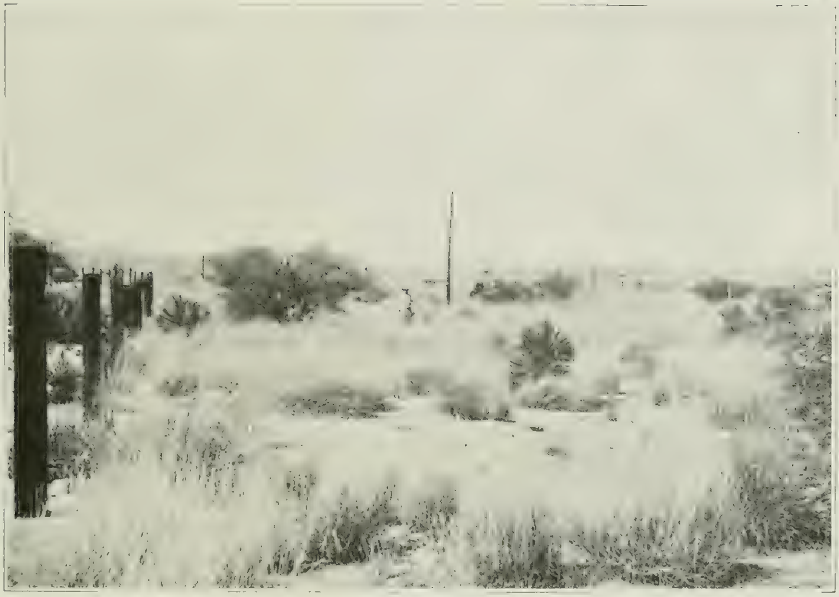

FIG. 1.—RAILROAD RIGHT OF WAY NEAR BENSON, ARIZ., SHOWING THE CONDITION OF THE RANGE UNDER PROTECTION.

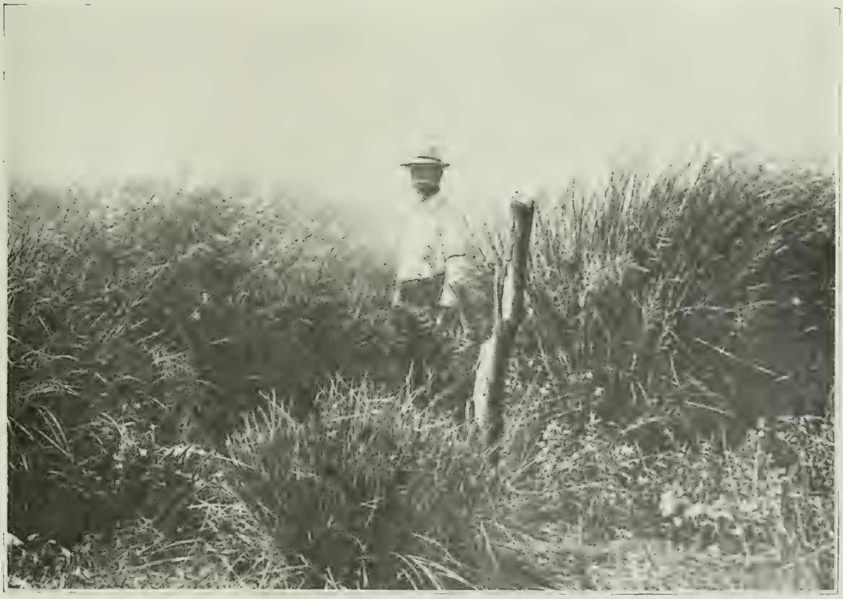

FIG. 2.—WRIGHT'S SACCATON (SPOROBOLUS WRIGHTII).

The Santa Cruz bottoms near Tucson, Ariz., are said to have been covered with this grass.

and attain success in our range-improvement investigations. This information can only be furnished by reliable and experienced men who are conversant with the condition of the grazing lands of the Territory at the time when they yielded profit to the rancher.

You have been recommended to us as a person who, on account of your wide experience and abundant opportunity of observation, will be able to give us the information desired. We hope that you will be willing to assist us in this matter, in which we are all so deeply interested, by answering as many of the inclosed questions as you can at your earliest possible convenience, sending your answers to us in the inclosed addressed free envelope.

Very truly yours,

David Griffiths,
Special Agent in Charge of Cooperative Work.

1. With what portions of the Territory are you especially familiar?

2. How long have you been acquainted with the regions spoken of in question 1?

3. What was the relative abundance of the feed on the native range at the time you first became acquainted with it, compared with the present time?

4. Will you please compare the grazing conditions in two or more regions with which you are familiar: for instance, the Santa Cruz, San Pedro, and Sulphur Spring valleys?

5. Can you describe any specific instances of the destructive action of water in gullying out the river valleys? Can you state how and at what time such gullying started in any particular instance, and the extent to which the washing progressed in a given time?

6. What influence has this gullying had on the productiveness of the river bottoms?

7. What grasses or other native forage plants furnish the greatest amount of feed at the present time in your vicinity? (If you do not know the names of these plants and are willing to send us samples, so state in answer to this question, and we will send you franks so that you can forward the same to us free of charge.)

8. Do you attribute the present unproductive condition of the range to overstocking, drought, or to both combined? Please explain why.

9. Will you please state the largest number of cattle which, in your opinion, have at any time grazed on any particular range with which you are acquainted, and at what time? What do you estimate is the present carrying capacity of the same range?

10. Provided we should be able to furnish seed, would you be willing to put it in the ground in proper shape in some favorable situation on your place where cattle will not graze it for at least one year after planting? A very small patch would be required, say 50 feet square. Such an experiment would enable us to determine what forage plants are best adapted to your locality.

ANSWERS TO QUESTIONS.

The answers returned have been very suggestive and indicate an intelligent, active interest in the questions which are of such vital importance to the stock growers located on the public domain. Two of these, however, appear of such general excellence and indicate such a keen insight into the forage problems that they are reproduced in full. Col. H. C. Hooker, one of the earliest and most successful stock raisers in the Territory, under date of December 11, 1900, writes as follows:

1. The southeastern.

2. Thirty-five years.

3. Fully double.

4. These regions have been diminished in grazing facilities fully 50 per cent in twenty-five years.

5. The San Pedro Valley in 1870 had an abundance of willow, cottonwood, sycamore, and mesquite timber, also large beds of saccaton and grama grasses, sagebrush, and underbrush of many kinds. The river bed was shallow and grassy and its banks were beautiful with a luxuriant growth of vegetation. Now the river is deep and its banks are washed out, the trees and underbrush are gone, the saccaton has been cut out by the plow and grub hoe, the mesa has been grazed by thousands of horses and cattle, and the valley has been farmed. Cattle and horses going to and from feed and water have made many trails or paths to the mountains. Browse on the hillsides has been eaten off. Fire has destroyed much of the shrubbery as well as the grass, giving the winds and rains full sweep to carry away the earth loosened by the feet of the animals. In this way many waterways have been cut from the hills to the river bed. There is now little or nothing to stop the great currents of water reaching the river bed with such force as to cut large channels and destroy much of the land under cultivation, leaving the river from 10 to 40 feet below its former banks. Thus it has caused much expense in bringing the water to the cultivated lands, and necessitated much labor to dam up the channel and keep the irrigating ditches in repair.

7. Gramas, saccatons, bunch, and six-weeks grasses.

8. Principally to overstocking. In times of drought even the roots are eaten and destroyed by cattle, while if not fed down or eaten out the roots would grow again with winter moisture.

9. There were fully 50,000 head of stock at the head of Sulphur Spring Valley and the valley of the Aravipa in 1890. In 1900 there were not more than one-half that number and they were doing poorly.

10. I will place 1 acre or more under fence on my land in any situation you may select for your experiments, providing you will superintend the planting and direct the cultivation, taking from my ranch such teams, farming tools, employees, etc., as you may require.

I am, respectfully yours,
H. C. HOOKER,
Proprietor Sierra Bonita Ranch.

Mr. C. H. Bayless, of Oracle, Ariz., in addition to answering questions, submitted a statement containing a forcible expression of the futility of attempting to control the range without the help of the Government or the ranchers. It appears to the writer that the ranchers and those interested in stock growing are beginning to realize more and more the importance of placing the range management in the hands of some one having authority and an interest in its preservation. The objection to the control of the range is gradually wearing away. At least a dozen ranchers have expressed themselves to me within the past year in fully as emphatic terms as Mr. Bayless in his letter quoted below. With reference to range management Mr. Bayless writes as follows:

DEAR SIR: Within find answers to questions sent me. Permit me to add that no practical plan can well be advanced for increasing plant growth on any open

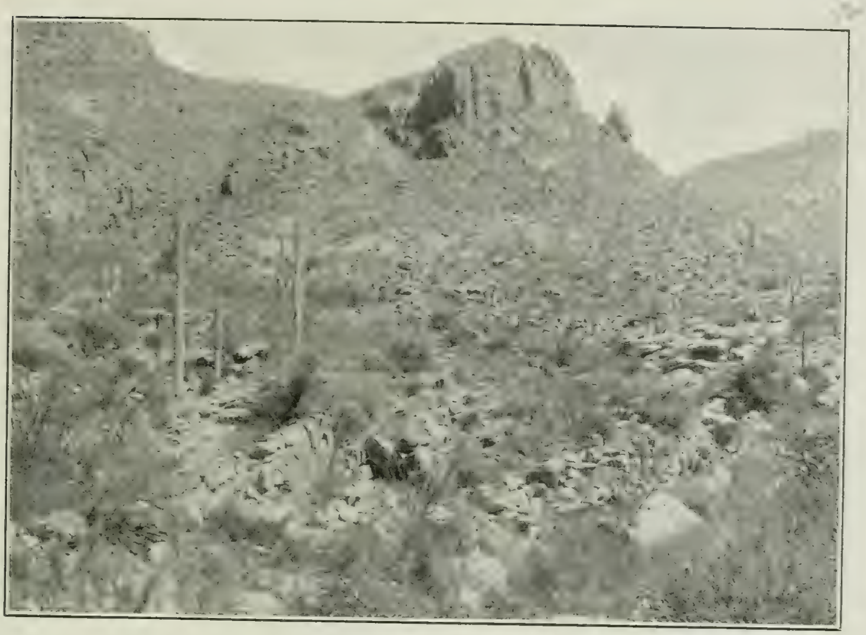

FIG. 1.—A CATTLE RANGE IN THE SANTA CATALINA MOUNTAINS, APRIL, 1901.

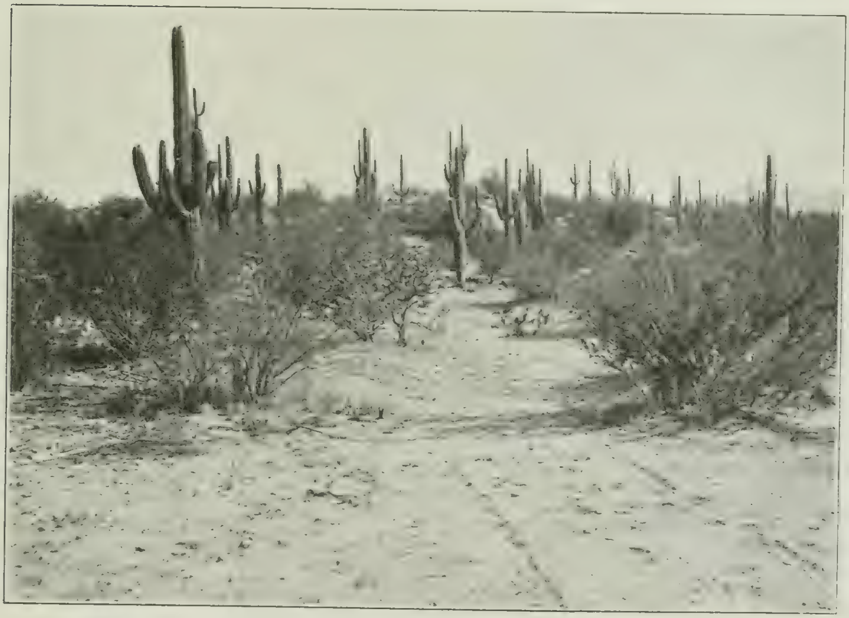

FIG. 2.—A FOOTHILL RANGE NEAR TUCSON, ARIZ., APRIL, 1901.

range while free for the use of everybody. Hence I must respectfully urge upon you the importance of impressing the Government officials with the fact that no general improvement of range country can be expected until the land is placed under individual control by lease or otherwise. In a few favored spots where such an arrangement is now secured through local conditions good results might be accomplished, but the greater part of our range country is at present a desert and will steadily become less and less productive, while the present range management, or rather lack of it, prevails.

Very respectfully yours, C. H. BAYLESS.

---

1. The San Pedro Valley and southern part of Pinal County.

2. Fifteen years.

3. At that time ten animals were kept in good condition where one can now barely exist. However, those ten animals were then rapidly destroying the vegetation, not making proper use of it.

5. About twelve years ago the San Pedro Valley consisted of a narrow strip of subirrigated and very fertile lands. Beaver dams checked the flow of water and prevented the cutting of a channel. Trappers exterminated the beavers, and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. Every year freshets are carrying away new portions of the bottom lands. At present this valley is a sandy waste from bluff to bluff, while the few fields remaining are protected from the river at large and continuous expense. Thus, in addition to curtailing the area of good land, the deep channel has drained the bottoms, leaving the native grass no chance to recover from the effects of close pasturing. It also makes it more difficult to get irrigating water onto the surface of the land.

7. Of the rich grama grasses that originally covered the country so little now remains that no account can be taken of them. In some parts of the foothills alfilaria furnishes limited but excellent pasture during the spring and early summer. Where stock water is far removed some remnants of perennial grasses can be found. Grasses that grow only from seed sprouted by summer rains are of small and transitory value. The foliage of the mesquite and catsclaw bushes is eaten by most animals, and even the various cacti are attempted by starving cattle. However, the thorns and spines of the cacti more than offset the value of the pulp. No better pasture was ever found in any country than that furnished by our native grama grasses, now almost extinct.

8. The present unproductive conditions are due entirely to overstocking. The laws of nature have not changed. Under similar conditions vegetation would flourish on our ranges to-day as it did fifteen years ago. We are still receiving our average amount of rainfall and sunshine necessary to plant growth. Droughts are not more frequent now than in the past, but mother earth has been stripped of all grass covering. The very roots have been trampled out by the hungry herds constantly wandering to and fro in search of enough food. The bare surface of the ground affords no resistance to the rain that falls upon it and the precious water rushes away in destructive volumes, bearing with it all the lighter and richer particles of the soil. That the sand and rocks left behind are able to support even the scantiest growth of plant life is a remarkable tribute to our marvelous climate. Vegetation does not thrive as it once did, not because of drought, but because the seed is gone, the roots are gone, the soil is gone. This is all the direct result of overstocking and can not be prevented on our open range where the land is not subject to private control.

9. Twelve years ago 40,000 cattle grew fat along a certain portion of the San

Pedro Valley where now 3,000 can not find sufficient forage for proper growth and development. If instead of 40,000 head 10,000 had been kept on this range, it would in all probability be furnishing good pasture for the same number to-day. Very few of these cattle were sold or removed from the range. They were simply left there until the pasture was destroyed and the stock then perished by starvation.

10. Yes, I will do so gladly. Object lessons of this kind will prove conclusively that overstocking, not drought, has made our country a desert.

C. H. Bayless, *Oracle, Ariz.*

FEED ON THE RANGE.

While each valley in the Territory has some characteristics distinctly its own, and while there is a great difference in the extent to which overpasturing has been carried on, there is still a certain similarity which is characteristic of the entire southern portion, namely, the preponderance during certain seasons of the year of weedy plants that would not ordinarily be considered fit food for cattle. During the year five typical valleys have been visited, namely, the Gila, Salt River, Santa Cruz, San Pedro, and Sulphur Spring. The opportunities for observation in the first two named were very meager, but still sufficient to bear out the testimony of several ranchers, that the only pasturage of any account in these two valleys during a large portion of the year consists of "browse." The main stock food on the open range appears to be derived from the mesquit and sage brushes (*Atriplex* spp.). These are supplemented in the winter and spring by weedy growths, and in the fall by annual grasses of transitory value. In the Santa Cruz Valley conditions are much the same on the open range, but in the Sulphur Spring Valley, which has a greater altitude, as well as a more copious precipitation, the perennial grasses still thrive. In some portions of this valley the natural conditions are such that the ranchers are able to control the range in such a manner as to protect it. No finer object lesson could be desired than the one furnished on the Sierra Bonita ranch, owned by Col. H. C. Hooker. This is located at the head of the valley, and the range is so situated between the Graham Mountains on the east and the Galiuro Mountains on the west that the entrance of cattle from neighboring ranches is easily prevented. Under such conditions, accompanied by good management, the range has been kept in a very good condition, compared with all the other portions of the region which the writer has visited. On this range large quantities of native grass are cut for hay. In one stack the following were recognized: Everlasting grass (*Eriochloa punctata*), *E. aristata*, *Chloris elegans*, *Eragrostis neomexicana*, vine mesquite (*Panicum obtusum*), *Aristida* spp. (in small quantities), Arizona millet (*Chaetochloa composita*), blue grama (*Bouteloua oligostachya*), low grama (*B. polystachya*), and *Andropogon torreyanus*. These, together with two or three species of *Sporobolus* (saccaton grasses) and the cultivated Johnson

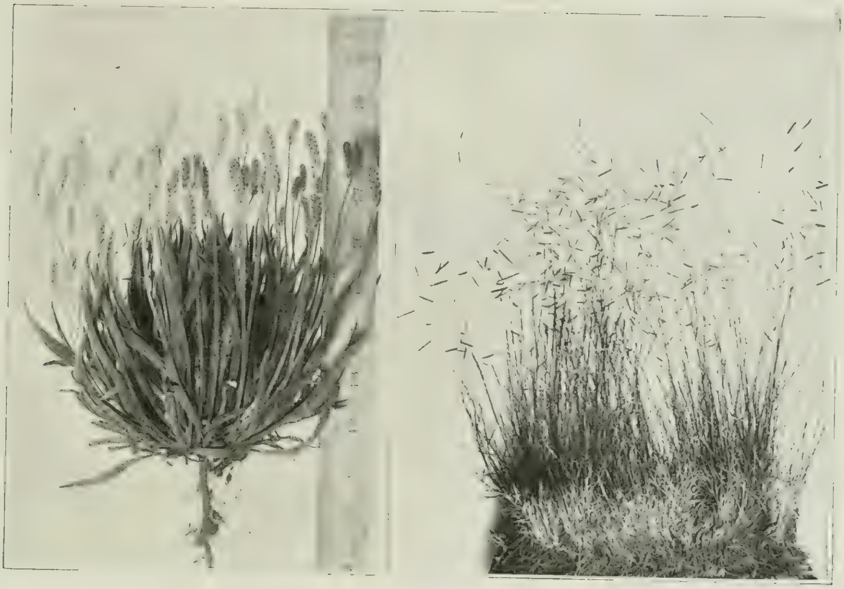

FIG. 1.—TUFTED PLANTAIN (PLANTAGO FASTIGIATA) ON THE LEFT; BLUE GRAMA (BOUTELOUA OLIGOSSTACHYA) ON THE RIGHT.

Both figures from plants growing near Tucson, Ariz.

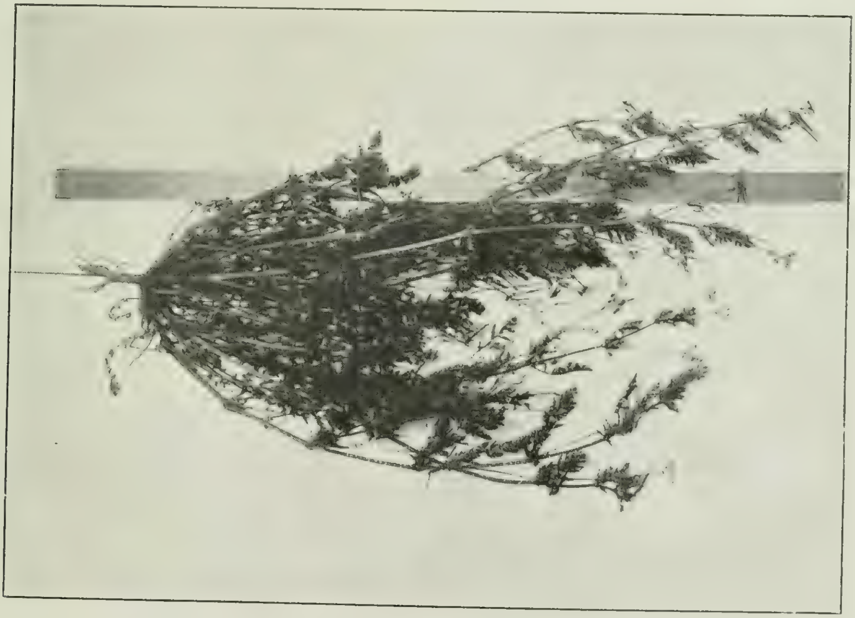

FIG. 2.—ALFILARIA (ERODIUM CICUTARIUM), GROWN ON THE UNIVERSITY CAMPUS AT TUCSON, ARIZ.

grass, form the main hay grasses on the range. In some localities the galleta grasses (*Hilaria mutica* and *Hilaria jamesii*) furnish large quantities of coarse hay, which, as one liveryman expressed it, is used to "chink" in with. The condition of the vegetation in the San Pedro Valley, while much superior to that of the Santa Cruz, is much inferior to the Sulphur Spring.

THE PLANTAINS.

These plants, of which the Indian wheat (*Plantago fastigiata* Morris) is the most important and which formed the greater part of the feed on the range in the vicinity of Tucson in the spring of 1901, are popularly known as Indian wheat and are very abundant after winter rains all through southern Arizona, especially in the lower altitudes. They are also found commonly at considerable elevations in the mountains, but are not sufficiently abundant there to be of any economic importance. On the lower moister areas of the general mesa region, however, the crop is often quite large. The fenced portion of our range reserve afforded an excellent opportunity for studying these plants during the past season. It is usually impossible to appreciate their entire forage value upon the open range on account of the present short pasturage. During the past season there was considerable difference in the quantity of these plants found inside and outside of our fenced area, although the feed is reported to have been more abundant than usual and the stock on the range to have been much reduced in recent years.

At the suggestion of Director R. H. Forbes an attempt was made to ascertain the precise amount of feed which these plants furnished on our range reserve tract during the past season. The estimate is believed to be approximately accurate and to give a very fair idea of the amount which grows in similar localities in rather favorable years. The estimate was made from actual measurements of representative areas selected by myself after a careful survey of the entire fenced area. A die 15 feet long by 3 feet wide was prepared as accurately as possible. All plantains covered by this were pulled up. After having the roots cut off they were placed in a bag and dried in the sun. Eighteen such areas were measured and treated in the same way. The weight of this material collected on the 26th and 27th of March became constant early in May, indicating that it was thoroughly dried. The final weights were then taken. The data given below indicate not only the amount of forage, but also the character and diversity of product of the reserve tract. The figures on the plat (p. 22) corresponding with the samples in the tabulation given below, indicate the localities where measurements were made. From these an idea of the relative productivity of the different situations can be readily obtained. It will be seen that the smallest growth occurred in the higher areas, occupied principally by the creosote bush (*Larrea mexicana*).

Number of plat.	Weight of dry material per acre.	Number of plat.	Weight of dry material per acre.	Number of plat.	Weight of dry material per acre.
	Pounds.		*Pounds.*		*Pounds.*
1	1,184	7	342	13	152
2	16	8	76	14	388
3	1,160	9	1,286	15	2,466
4	1,139	10	1,036	16	153
5	2,347	11	56	17	1,594
6	1,079	12	3,087	18	300

By comparison with the diagram on page 22, it will be seen that the smaller weights in the table indicate areas where the creosote bush predominates. These average the smallest in quantity, varying from 16 to 2,466 pounds per acre. An average of these plats gives a yield of 992 pounds or practically one-half ton per acre, or 166½ tons for the entire 336 acres under fence. The value of this material for stock food must be determined by actual feeding tests and chemical analysis. This the Station is now planning to determine. It may be said, however, that Indian wheat forms a large part of the feed on the range during late winter and spring, and that cattle pastured on it and alfilaria, while not in as good condition as those fattened on the ranges of the Northwest, were still in fair condition for the market.

These plantains appear especially well suited to grow on the sandy desert mesa, where winds and destructive floods are liable to carry away the seed. The method of seed distribution is indeed unique and one of the most interesting the writer has ever seen. As far as observed there appears to be no special method for scattering the seeds, but when the capsule is ruptured they fall, being scattered only by chance influences of vegetation and wind. Each seed is surrounded by a hyaline mucilaginous covering which is ordinarily inconspicuous when the seed is dry. When the seeds scattered over the surface of the ground are moistened, as by a shower of rain, this covering swells, becomes mucilaginous, and attaches itself temporarily to particles of earth or to whatever it comes in contact with. After becoming thoroughly moistened the seed gravitates to the bottom of the mucilaginous covering and rests upon the supporting soil. Upon the evaporation of the absorbed moisture the mucilage dries in such a way as to leave the seed in the bottom of a small pit in the ground. This depression has usually a diameter about three times that of the seed and a depth equal to or slightly greater than the distance between its flat surfaces. The abrading of the surface during the subsequent two to five months, during which the seeds lie dormant, serves to effectually cover them, so that they are ready for germination upon the advent of the summer rains. Just what the mechanism is

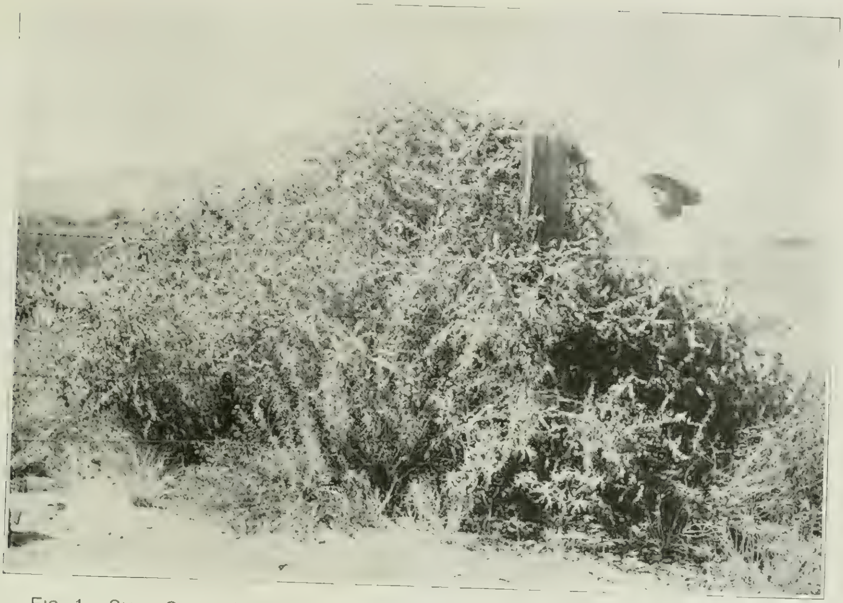

FIG. 1.—SHAD SCALE (ATRIPLEX CANESCENS) IN FENCED FIELD NEAR TUCSON, ARIZ.

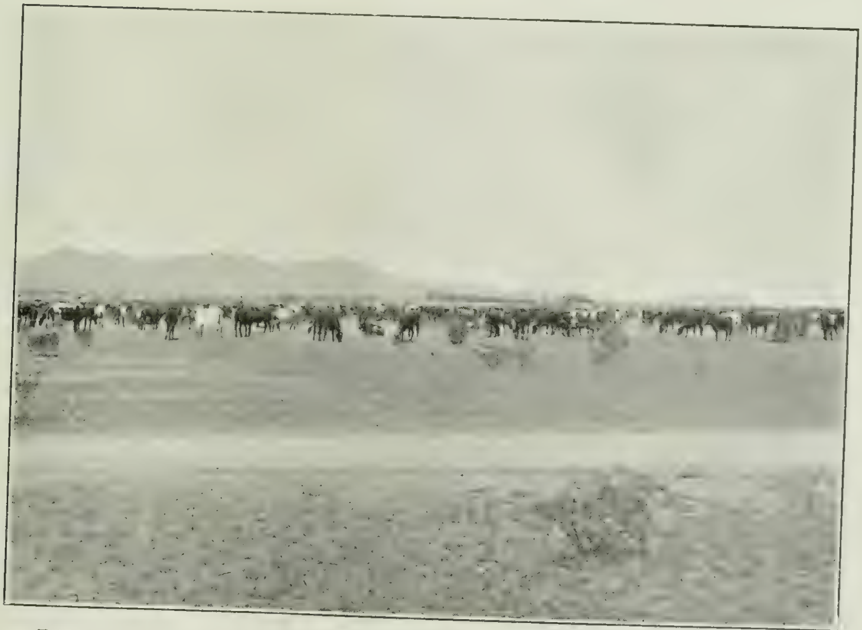

FIG. 2.—CATTLE FED ON TUFTED PLANTAIN (PLANTAGO FASTIGIATA) AND ALFILARIA (ERODIUM CICUTARIUM) ON WAY TO MARKET, MAY, 1901.

which serves to sink the seed into the ground has not been determined by this study. When moistened the gelatinous covering has a distinct radial, striated structure, and the surface of the pit would indicate that in some way the earth is pulled away from the seed, thereby allowing it to sink into the ground. The process is so effectual as to cause the seed to be sunk even in hard roadbeds as well as upon the general surface of the mesa. A study of this problem for the purpose of determining exactly the influence of this mucilaginous covering in the burial of the seed would throw considerable light upon the development of these plants in unfavorable desert regions, and doubtless add something to our knowledge of seed distribution. The amount of seed produced in the spring of 1901 was exceedingly large. Considerable areas on our range reserve were completely covered with it. A shower of rain on the 26th of May served to make it very conspicuous. Naturally every cow track, gopher hole, and other depression was filled with it. When the rain fell these masses of seed became firmly united together, sometimes into thin crusts and sometimes into masses 3 inches or more in thickness. Upon drying the mesa presented a peculiar appearance, for these cakes curled in much the same manner as a muddy deposit on the bottom of a dried-up pool. Many localities have been seen where a third of the ground was covered for an acre or more in extent with cakes of this seed. When moistened in large masses a crust was invariably formed on the top and bottom in a short time after the shower passed by. In both crusts the seeds were relatively abundant. In the upper crust this appeared to be due to rapid drying, but in the lower one it was evidently due to gravitation, whereby the seeds were deposited on the bottom, where they were incrusted with particles of earth, leaving the mucilage more nearly pure in the center of the mass.

Mr. James Goodwin, of Tempe, reports that the seeds of these species of plantain are largely used for food by the various Indian tribes of Mexico. A beverage is prepared by soaking the seeds in water and sweetening with sugar. In this way a sirupy liquid is obtained which is said to be very nutritious.

SALTBUSHES AND THEIR ALLIES.

These "browse" plants are popularly known as sage brush in Arizona, although very different from the artemisias of the Northwest, which are referred to by the same name. Every rancher is acquainted with this portion of the stock feed of the region, but it has appeared to me that its full value is not appreciated. The most important of the species observed is shad scale (*Atriplex canescens*), although several others, both of the perennial and annual groups, occur in large quantities. These are grazed to a greater extent in the Santa Cruz Valley than in any other region visited. Here it is very seldom that one encounters a plant over 2 or 3 feet high on the open range, while in protected places bushes 10 feet high may often be seen. Large areas of a luxuriant growth of these plants were formerly found along the Santa Cruz River, where now only short stumpy growths 10 or 12 inches high are to be found. It is on the plains to the westward and in the Gila and Salt River valleys, however, that these plants grow in the greatest profusion. Here, as the writer's observation goes, they are but slightly injured by grazing. This appears especially true in the vicinity of Tempe. In one locality on the Gila, however, as well as at Tombstone, in the San Pedro Valley, close cropping of shad scale was the rule.

The propagation of the native species of *Atriplex* has been attended with considerable difficulty, but some plantings made on the range in January have proven very successful. In the case of shad scale, which appears to be the most promising of any of the native species, the seed collected by various field agents of the Division in the Northwest have usually failed to germinate. This was also the case with seed collected in Arizona early in September of 1900. The same material collected a month later germinated readily. The difference could not be one of local conditions or difference of treatment, because these conditions were identical and the same results were obtained on the range and in germination tests in the greenhouse. A favorable time for collecting seed of the native species which occur in this region is late October to January. It will probably grow just as well if collected in late October as at any other time, but gathering can be done to better advantage later in the season, because the seeds strip off more readily and require less drying—circumstances of considerable importance to the seed collector. In the moister alkaline regions the greasewood (*Sarcobatus vermiculatus*) is often found in abundance, but observation indicates that it is not browsed as much as one would expect. It is certainly a much inferior food to the saltbush. Winter fat (*Eurotia lanata*), on the contrary, appears to be nearly exterminated on the open range. Two or three bushels of seed could have been gathered on the railroad right of way between Dragoon and Cochise in October, but on the open range only two or three closely cropped bushes were to be found. This is the only place in which the plant has been collected.

NATIVE LEGUMES.

The most important plant among the legumes is the mesquit (*Prosopis velutina* Wooton?[1]). The screw bean (*P. pubescens*) is also common, but it never grows in such profusion as the other closely related species. So much has been written regarding the forage value of this plant that but little need be said in this place. In this region it forms much of the feed during the hard times, not only in spring and early summer while it is succulent and green, but also in the winter, when it would be ordinarily considered worthless. During the past winter, when the pastures along the Santa Cruz were very short, not only the pods but the leaves of this tree as well were eaten by cattle. Numerous instances were observed where the leaves as they fell from the trees were completely cleaned up in large areas in the thick mesquit groves of the region.

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[1] The prevailing species in southern Arizona has been referred to *P. juliflora*. It is not, however, the same plant that is referred to this species in Texas and the greater part of New Mexico. The Arizona plant corresponds closely in everything but fruit characters to *P. pubescens*.

Besides the mesquit there are several species of *Acacia* which are browsed to some extent. The leaves of these are also eaten after they have fallen in much the same manner as the mesquit during times of short feed. Many species of *Lupines*, *Horsackias*, and *Astragalus* abound and furnish a large part of the feed on the moister mesas and foothills for a short time in the spring. *Astragalus nuttallii*, which is the common species in the moister mesa region, is worthy of special mention. It is readily eaten and under favorable conditions furnishes much palatable feed. Several small areas on the range reserve tract had a complete covering of this plant during the past spring. It is a small plant, but has the advantage of forming such a dense growth as to completely cover the ground. Its seeds are also comparatively easily collected. If gathered before fully ripe the whole plant with its abundant seed supply can be collected, but if left until the herbage is dead and dry the pods can be scraped up from the ground with little, if any, loss of seed.

THE CACTACEÆ.

The cactuses look very uninviting to the average stock raiser, but they, nevertheless, are of some value and are resorted to in times of great necessity. During the past winter at least a half dozen instances were observed of the actual eating of these plants by cattle. The species most frequently made use of in the vicinity of Tucson are *Opuntia fulgida*, *O. spinosior*, *O. versicolor*, and *O. arbuscula*. The two named first produce an abundance of fruit which is free from large spines. The former has many bunches of small fruit, while the latter has large fruits borne singly. One may often during a hard winter observe cattle having a dozen or more joints of this species attached to their heads and necks. Usually these joints remain in these positions until they are rubbed off or until they fester and drop out of their own accord. Fragments of these plants break off very readily, and cattle reaching under the joints to obtain the fruit are almost certain to come in contact with one or more of them.

Knowing of the experiments conducted in Texas of feeding these plants (*O. engelmanni* especially), in January, the experiment of singeing the spines as thoroughly as possible from a portion of a medium-sized specimen of *O. spinosior* was tried. About one-third of the plant was left unsinged. Ten days later, when the locality was again visited, the singed portion had all been eaten down to the old hard wood. As near as could be judged the greater part of three years' growth had been eaten. The cattle were doubtless attracted by the small quantity of hay (used in the singeing) that was scattered over the ground. It is well known that these plants, at certain times of the year at least, are very rich in starch, and for that reason may be more nutritious than one would be led to believe. To what extent this form of vegetation, so abundant on the mesas of this region, can be utilized as cattle food in time of scarcity is not known. Neither is it known whether the plants will survive the singeing process. Two experiments were started for the purpose of determining the latter point, but engagements compelled the writer to leave the region before any conclusion could be reached. The singeing of the giant cactus (*Cereus giganteus*) is said to have been a common practice among the Indians in former times. By lighting the spines of the giant Cereus they gave momentary signals to their friends in the distance. Many of these plants with burned spines were encountered during the the past season in full bloom and in apparently healthy condition. Whether the other species will bear the same treatment remains to be determined. It is certain that the spines alone prevent their being eaten more extensively by cattle.

THE GRASSES.

As usual in every range the grasses form the bulk of cattle food. Other plants are more or less important, because they serve the very useful purpose oftentimes of tiding over periods of short pasturage. While the bulk of the feed in many localities for the greater part of the year is obtained from the grasses, the other vegetation mentioned above serves the very vital purpose of furnishing a subsistence ration when the more nutritious and palatable grasses fail entirely. It is for this reason that the species of *Plantago*, *Atriplex*, and *Erodium* are of so much importance and the *Cactaceæ* are mentioned as being of possible utility.

At the present time perennial grasses are rarely found on the general mesa in the Santa Cruz Valley in the vicinity of our experimental tract, unless it be in an occasional stray bunch protected by the thorns of the mesquit or the spines of the cactus. In the protected places along the river bottoms are still found excellent growths of saccaton (*Sporobolus wrightii*). This has been to a large extent exterminated in recent years for agricultural purposes, so that the only places in which it is found at the present time are in an occasional pasture or in uncultivated portions of fenced fields. It is one of the most persistent of the native species of the region. The woody character of the culms prevents its being grazed closely, which, no doubt, has

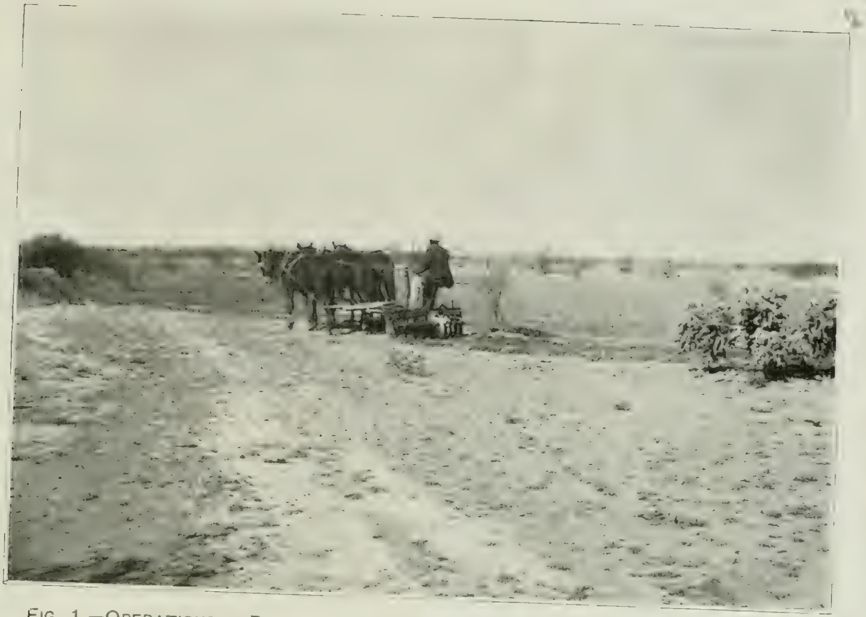


FIG. 1.—OPERATIONS IN RANGE IMPROVEMENT NEAR TUCSON, ARIZ., JANUARY, 1901.

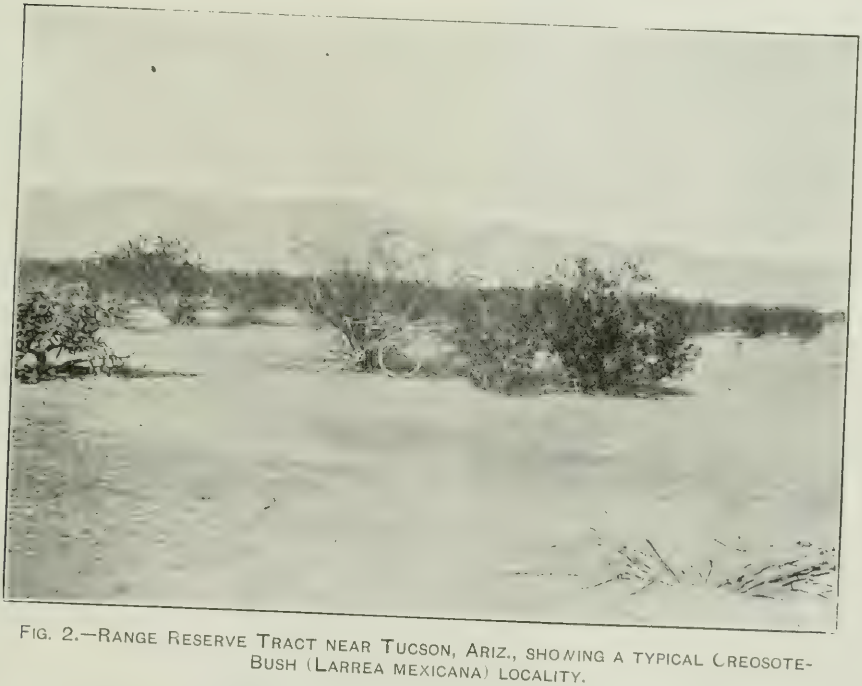


FIG. 2.—RANGE RESERVE TRACT NEAR TUCSON, ARIZ., SHOWING A TYPICAL CREOSOTE-BUSH (LARREA MEXICANA) LOCALITY.

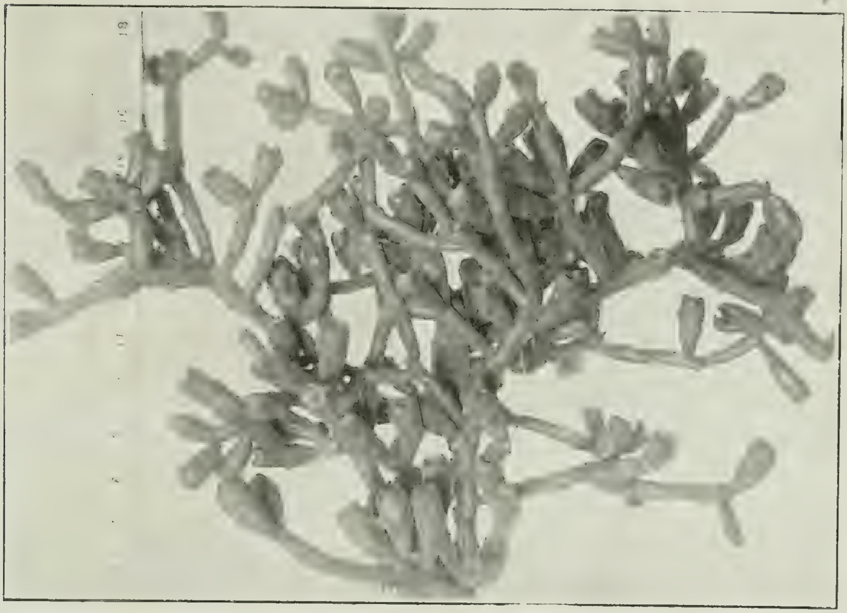


FIG. 1.—CACTUS (OPUNTIA ARBUSCULA) FROM RANGE RESERVE TRACT NEAR TUCSON, ARIZ.

The fruit is eaten by cattle during short pasture.

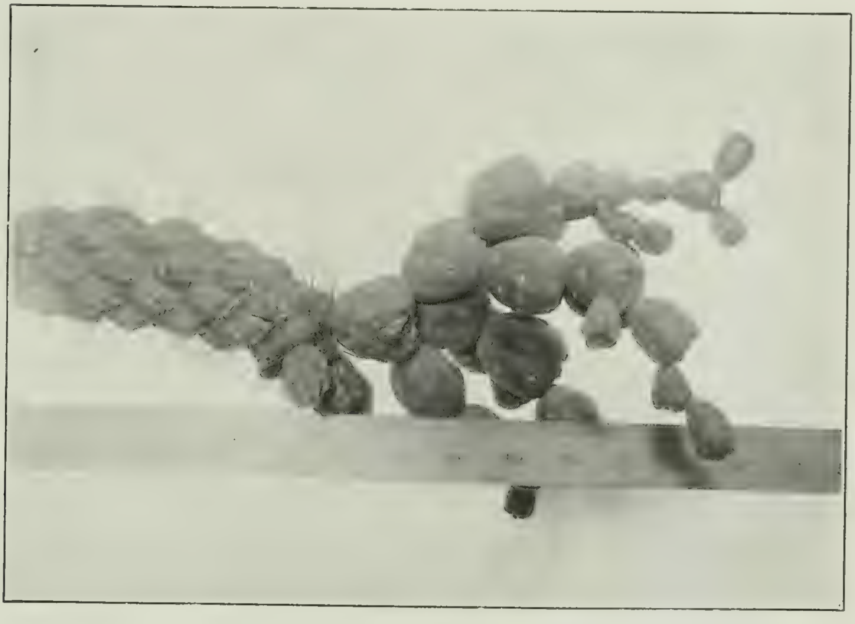


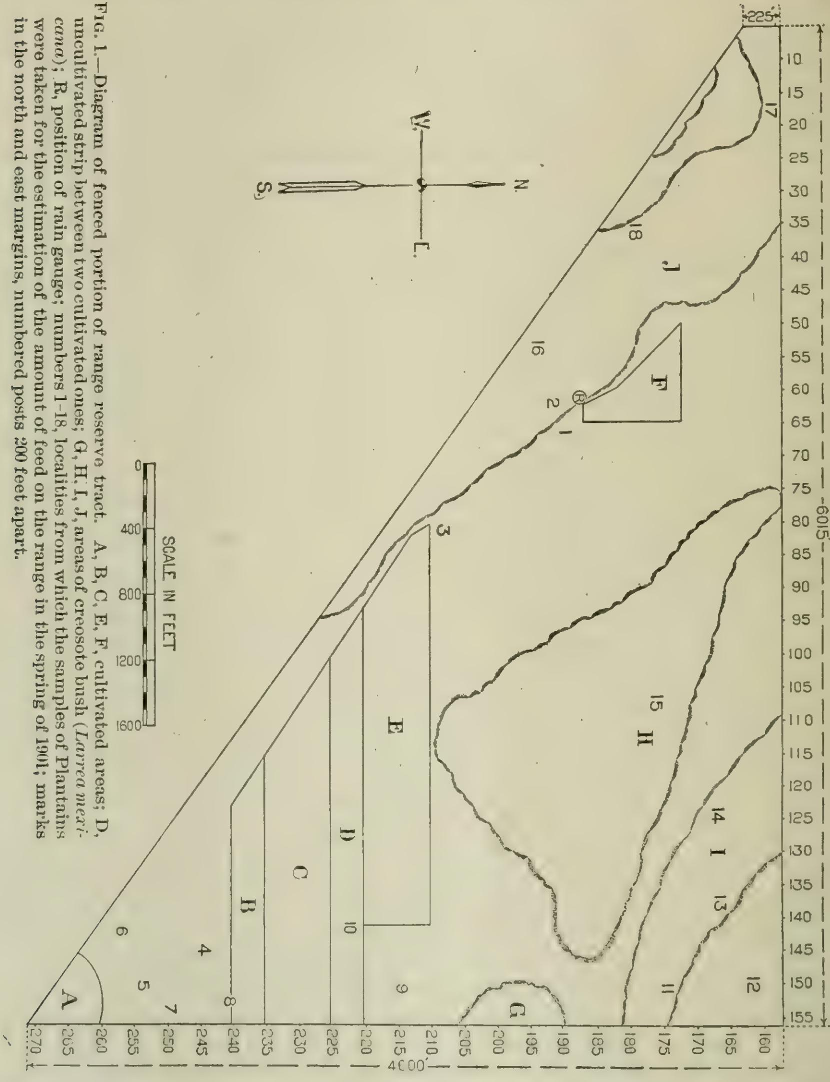
FIG. 2.—CACTUS (OPUNTIA FULGIDA). A BUNCH OF PENDANT FRUIT AND ONE JOINT.

In extreme cases of hunger cattle feed on this fruit.

much to do with its persistency under heavy pasturing. It has been reported to me that the expense of clearing a piece of ground of saccaton is as great as the clearing of an equal area of mesquit timber. The feed from this source is very coarse and is usually considered of an inferior quality, but, like the saltbushes, it furnishes feed when nothing else can be found. Of similar utility is the salt grass (*Distichlis spicata*), which is grazed to a large extent during seasons of of short feed. It is much inferior in feeding quality to the saccaton. During the dry season of 1900 it is said to have saved many herds of cattle from starvation in the Sulphur Spring Valley, where there are thousands of acres of it and where either from the effect of alkali or overstocking nothing else grows. On sandy portions of the river bottoms may be found considerable quantities of drop-seed (*Sporobolus cryptandrus*), *S. strictus*, and Arizona millet (*Chætochloa composita*).

The most important nutritious grasses which predominate on the open mesa range are black grama (*Hilaria mutica*), *H. jamesei*, curly mesquite (*H. cenchroides*), blue grama (*Bouteloua oligostachya*), low grama (*B. polystachya*), wolly-foot (*B. eriopoda*), side oats grama (*B. curtipendula*), and black heads (*Pappophorum wrightii*). In depressions where water accumulates after summer rains good growths of *Chloris elegans*, everlasting grass (*Eriochloa punctata*), vine mesquite (*Panicum obtusum*), *P. colonum*, and *Eragrostis neomexicana* are found. In such moist localities, where close pasturing is not the rule, there may usually be found also fine growths of feather grass (*Andropogon torreyanus*). This grass, however, is never seen on the unprotected range in any quantity. Large areas were encountered on the railroad right of way in the vicinity of Cochise in 1900. On the open range one seldom finds it, except where protected by the thorns of the mesquite or spines of the cactus. On the general mesa, where the soil does not wash badly, there are invariably found large quantities of six weeks grama (*Bouteloua aristidoides*) after the summer rains. This species, known popularly as six-weeks grass, furnishes a great deal of excellent feed for a short time. Besides the above should be mentioned several species of *Muhlenbergia* and *Aristida*, which for short periods furnish much feed of an inferior quality. The preceding description would apply fairly well for 1900 to the Sulphur Spring Valley. The quantity diminished gradually to the westward as far as Tucson, where, although the species mentioned above were commonly found, there was but little feed furnished by the native grasses. During the second week in October large areas on the gentle slopes near the foothills in the San Pedro Valley were very fairly covered with short growths of *Bouteloua aristidoides*, *B. polystachya*, *Pappophorum wrightii*, and *Nazia aliena*.

The adaptability of the grasses, as well as the other vegetation in this region to conditions of environment, is something wonderful. Variation in size as the direct influence of quantity of moisture is often very marked. *Chloris elegans*, which commonly grows 2 feet high, may be often found on the drier mesas in scattering specimens maturing perfect seed when the whole plant above ground measures no more than an inch and a quarter in length. Six-weeks grama (*Bouteloua aristidoides*) is often reduced from the maximum of 12 inches in height, with a dozen or more branches, to a single culm three-fourths of an inch long, maturing but one or two spikelets. Corresponding variations in size are especially noticeable in all of the annual species.


N.
S.
E.
W.
SCALE IN FEET
0
400
800
1200
1600
225
6015
4000
A
B
C
D
E
F
G
H
I
J
R
1
2
3
4
5
6
7
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11
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18
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155
160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270

FIG. 1.—Diagram of fenced portion of range reserve tract. A, B, C, E, F, cultivated areas; D, uncultivated strip between two cultivated ones; G, H, I, J, areas of creosote bush (*Larrea mexicana*); R, position of rain gauge; numbers 1-18, localities from which the samples of Plantains were taken for the estimation of the amount of feed on the range in the spring of 1901; marks in the north and east margins, numbered posts 200 feet apart.

The mountain range presents a very characteristic appearance.

Receiving as it does a more liberal supply of moisture, the development is more uniform during the growing season. Even here no sod is formed, indeed no sod could usually be formed if the moisture conditions were ever so favorable, for the presence of loose jagged rocks, with the exceedingly rugged conditions, would almost compel the growth of grasses in small bunches. The grasses which form the main feed in such localities, and therefore the most conspicuous of this portion of the vegetation, are *Andropogon contortus*, *A. leucopogon*, *Trachypogon secundus*, *Elionurus barbiculmis*, *Hilaria* sp., *Bouteloua bromoides*, *B. oligostachya*, *B. curtipendula*, *Trioda mutica*, *Eragrostis lugens*, *Muhlenbergia gracillima*, *M. porteri*, *Epicampes rigens*, and *Aristida* sp. These regions are often so inaccessible that stock can not reach them. They are therefore more nearly primitive than the mesas, and one is able to get a better idea of their productivity.

THE RANGE RESERVE TRACT.

The range improvement work in Arizona being of a different character from that usually contemplated, and being in a region more completely divested of range grasses than any other in the entire country, required considerable careful study in advance to discover the proper locality for experimentation. Accordingly, the greater part of a week was spent in a survey of the surrounding country in the vicinity of Tucson for the purpose of determining which of the three typical areas (mesa, foothill, or river bottom) would be the most favorable and give the most conservative and valuable data upon which to base judgment of the results obtained by experimentation. Finally a rather favorable mesa area was selected at an altitude of about 2,600 feet above sea level and about 400 feet higher than the city of Tucson. This tract, which was subsequently reserved from entry at the request of the Hon. James Wilson, Secretary of Agriculture, is described in the Government surveys as secs. 26, 27, 34, and 35, T. 14 S., R. 14 E., Gila and Salt River meridian.

Somewhat diagonally through the center of this area runs the Southern Pacific Railway, and a short distance to the east of it is located Wilmot Siding. The soil is a clay loam, mixed with considerable sand, and subtended at a depth of 2 to 2½ feet by a calcareous hardpan, known among the Mexicans by the significant name "caliche." The slope, which is rather gentle, has a general northwesterly direction, and is traversed by three more or less distinct, broad, shallow depressions, which receive the drainage of a considerable area of land to the southeast. Such a region, with broad, shallow washes, was purposely selected. It was the intention to attempt to conserve water flow on the mesa, and to discover what can be done toward preventing "run-off" of water during the rainy season of July and August. Such washes, although the most favorable for the growth of vegetation of all kinds, are nevertheless typical of large tracts of desert, not only in the Santa Cruz, but in the San Pedro, Gila, and Salt River valleys as well.

A triangular portion of this reservation, consisting of 336 acres adjoining the Southern Pacific right of way, has been placed under a substantial four-wire fence supported on singed mesquite posts 13½ feet apart. The area encompasses nearly all the varieties of exposure, drainage, and soils, and is, in short, a typical mesa region in every respect. The advantage taken of the railway fence enabled us to inclose the tract at a minimum cost. Two miles of fence, at an approximate cost of $150 a mile, covers practically the entire expense of the inclosure.

When selected, this tract of land, like the surrounding region, furnished practically no feed; the ground was bare, except for cacti and shrubby growths of little or no forage value. On the higher and poorer soils are found characteristic growths of the creosote bush (*Larrea mexicana*), around the base of which is almost invariably found *Perezia nana*, which, unlike the vast majority of desert plants, possesses a very pleasant odor. Scattered over the entire area are to be found luxuriant growths of cacti, mainly of the genus *Opuntia*. The main species of this family are *O. fulgida*, *O. spinosior*, *O. arbuscula*, *O. engelmanni*, *Cereus fendleri*, *C. greggii*, *Echinocactus wislizeni*. All of the lower areas have scattering growths of mesquite (*Prosopis velutina*), palo verde (*Parkinsonia torreyana*), *Zizyphus lycoides*, *Lycuim* sp., *Riddellia cooperi*, *Bigelovia* sp., and *Ephdera trifurca*. A few specimens of *Yucca elata* are also to be found. These plants formed the conspicuous portion of the vegetation in September, when the land was selected, and there was no grass except an occasional tuft of six-weeks' grass (*Bouteloua aristidoides*) and low grama (*Bouteloua polystachya*). Soon after this date the tract assumed a more promising aspect, and weedy growths of various kinds began to spring up after the very light summer rains. It was not until January, however, that the vegetation became marked. From this time on until the 1st of March there was an abundant development of short-lived annuals. The most conspicuous of these was the California poppy (*Eschscholtzia mexicana*), which was so abundant in localities here and in other portions of the valley as to give its characteristic golden hue to the entire landscape, sometimes for many acres in extent. The next in abundance was Indian wheat (*Plantago fastigiata*), of which a description will be found elsewhere (p. 15). Besides these, there were a great many borages, which were often the characteristic vegetation over large areas. The principal genera of this family represented were *Pectocarya*, *Echidiocarya*, *Amsinkia*, *Echinospermum*, and *Eretrichium*. Among other conspicuous plants may be mentioned *Malacothix glabrata*, *Chænactis lanosa*, *Daucus pusillus*, *Bowlesia septentriolis*, *Erodium cicutarium*, *E. texanum*, *Salvia columbariæ*, and the peculiar *Œnothera scapoidea*. In a few localities conspicuous growths of the prickly poppy (*Argemone platyceras*) were to be seen. The latter was quite persistent and continued to bloom until June.

In this description no attempt is made to give a list of the plants growing on the fenced area. A sufficient number is given to show the character of the vegetation in the different seasons.

By the 1st of April the majority of the winter annuals were dried up, and a month later they were all quite dead and their seed had been scattered, so that all that was necessary to make the region look as it did the previous fall was to have the cattle eat off the dead herbage, which they were rapidly doing on the outside of the fence.

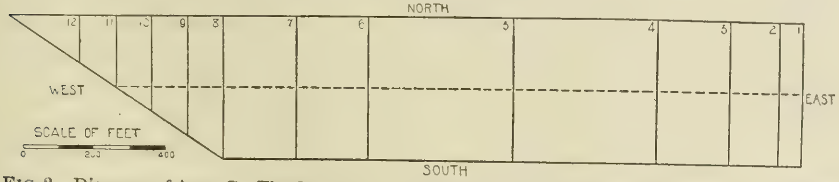

FIG. 2.—Diagram of Area C. The figures indicate the position of the stakes in each plot; broken line, separation between disked and harrowed portions.

The following detailed account of the forage plants planted is presented for comparison with figures 2, 3, 4, and 5, respectively.

AREA C.

Operations were begun on this plat on the 10th of January, immediately after a rainfall of 0.42 inch. After seeding the north half was disked and the south half harrowed directly east and west. The ground was conspicuously ridged by the disk harrow, and the seed was consequently covered to varying depths. Subsequent showers showed beyond a doubt that this ridging was an advantage in preventing a run off of water. The area is 400 feet in width by 2,200 feet in its greatest length. It measures 17½ acres and contains plats 1 to 12, on which were planted seed, as follows.

Number of plat.	Name of forage plant sown.	Seed, native or foreign.	Area of plat.
			Feet.
1	*Chloris elegans*	Arizona	400 by 60
2	Nothing sown		400 by 140
3	*Chloris elegans*	Arizona	400 by 40
4	do	do	400 by 40
5	*Andropogon saccharoides*	do	400 by 400
6	*Agropyron spicatum*	Northwest	400 by 200
7	*Agropyron occidentale*	do	400 by 200
8	*Hilaria mutica*	Arizona	400 by 100
9[a]	*Bromus unioloides*	(?)	350 by 100
10[a]	*Bromus marginatus*	Idaho	200 by 100
11[a]	*Pappophorum vaginatum*	Arizona	150 by 100
12[a]	*Eurotia lanata*	do	100 by 100

[a] The areas given for plats 9 to 12 are only approximate, for they, taken together, form a triangle, and the exact length of each plat has not been determined.

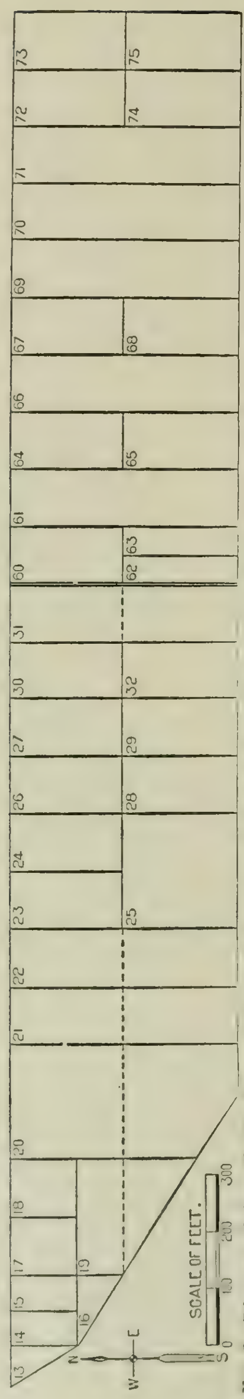

FIG. 3.—Diagram of Area E. The figures indicate the position of the numbered stakes in each plat; broken line, separation between harrowed and disked portion of west half; double line, west edge of portion disked before seeding.

AREA E.

This area, like C, extends directly east and west. The west half, consisting of plats 13 to 32, was sown without previous preparation of the ground. The south half of this portion was then disked and harrowed east and west, and the north half harrowed twice in the same direction. The east half, consisting of plats 60 to 75, was disked in an east and west direction before being planted and afterwards harrowed north and south. The entire area measures 400 feet in width by 2,400 feet in its greatest length, and contains 19½ acres. The seed planted here were as follows:

Number of plat.	Name of forage plant sown.	Seed, native or foreign.	Area of plat.
			Feet.
13 [a]	*Aristida bromoides*	Arizona	100 by 75
14 [a]	*Aristida humboldtiana*	do	110 by 62½
15 [a]	*Muhlenbergia gracilis*	do	110 by 62½
16 [a]	*Stipa* spp	New Mexico	100 by 60
17 [a]	*Chætochloa composita*	Arizona	100 by 110
18 [a]	*Melinus minutiflora*	Brazil	100 by 110
19 [a]	*Bromus unioloides*	Australia	100 by 200
20 [a]	*Eriocoma cuspidata*	(?)	400 by 200
21	*Sporobolus wrightii*	Arizona	400 by 100
22	*Sporobolus* (near) *wrightii*	do	400 by 100
23	*Sporobolus cryptandrus*	Colorado	200 by 100
24	do	Arizona	200 by 100
25	*Sporobolus airoides*	Wyoming	200 by 200
26	*Bouteloua polystachya*	Arizona	200 by 100
27	*Bouteloua curtipendula*	do	200 by 100
28	*Bouteloua humboldtiana*	New Mexico	200 by 100
29	*Bouteloua eriopoda*	Arizona	200 by 100
30	*Bouteloua aristidoides*	do	200 by 100
31	*Bouteloua polystachya* *Chloris elegans*	do	400 by 100
32	*Bouteloua oligostachya*	do	200 by 100
60	*Elymus simplex*	Wyoming	200 by 100
61	*Elymus canadensis* var	(?)	400 by 100
62	*Poa fendleriana* *Bouteloua eriopoda*	New Mexico	200 by 50
63	*Elymus ambiguus* *Poa lucida*	Montana?	200 by 50
64	*Elymus condensatus*	do	200 by 100
65	*Elymus virginicus submuticus.*	Washington	200 by 100
66	*Agropyron tenerum*	(?)	400 by 100
67	*Agropyron spicatum*	Washington	200 by 100
68	*Agropyron occidentale*	(?)	200 by 100
69	*Bouteloua oligostachya*	Arizona	400 by 100

[a] The measurements of plats 13 to 20 are only approximate.

Number of plat.	Name of forage plant sown.	Seed, native or foreign.	Area of plat.
			Feet.
70	*Bouteloua polystachya*	Arizona	400 by 100
71	*Bouteloua bromoides*	New Mexico	400 by 100
72	*Hilaria cenchroides*	Washington, D.C.	200 by 100
73	*Eragrostis neomexicana*	Arizona	200 by 100
74	*Bromus polyanthus paniculatus*	New Mexico	200 by 100
75	*Phraseolus retusus.*	do	200 by 100
	Phleum asperum	Washington	

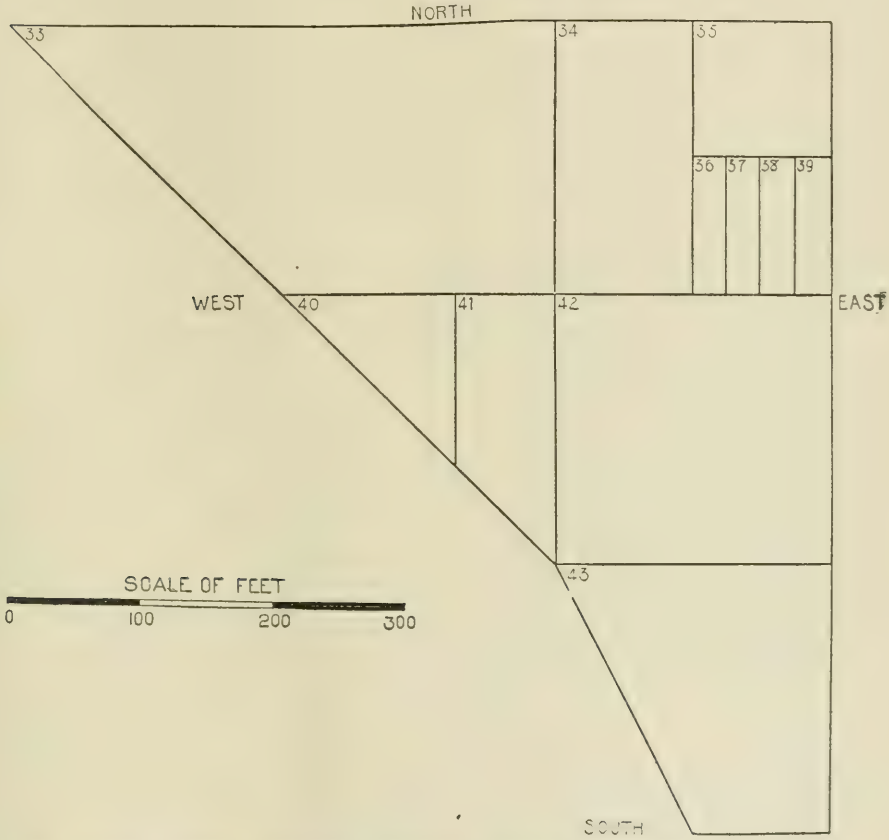

FIG. 4.—Diagram of Area F. The figures indicate the position of the numbered stakes in each plat.

AREA F.

This was devoted entirely to saltbushes, except that in a few plats seeds of native grasses were also sown. The area is located on the edge of one of the broad, shallow washes and is laid out roughly triangular, so that the measurements given for some of the individual plats are only approximate. It consists of plats 33 to 43 and contains nearly 4 acres. The cultivation here was more thorough than in either C or E. The saltbush seed was sown on the uncultivated soil. The ground was then disked north and south and east and west. The grass seed was then sown, after which the entire area was harrowed diagonally. Seed of saltbushes was planted in plats as follows:

Number of plat.	Name of forage plant sown.	Seed, native or foreign.	Area of plat.
			Feet.
33	*Atriplex canescens*	Tucson, Ariz	200 by 300
34	do	Tempe, Ariz	200 by 100
35	*Atriplex* sp	do	100 by 100
36	*Atriplex canescens*	Wyoming	100 by 25
37	*Atriplex erenicola*	do	100 by 25
38	*Atriplex nuttallii*	do	100 by 25
39	*Atriplex volutans*	do	100 by 25
40	*Atriplex halimoides*		100 by 125
41	*Elymus canadensis* *Atriplex halimoides*	(?) Australia	175 by 75
42	*Erocoma cuspidata* *Atriplex* sp	New Mexico Tempe, Ariz	200 by 200
43	*Bouteloua oligostachya* *Atriplex semibaccata*	Arizona California	200 by 150

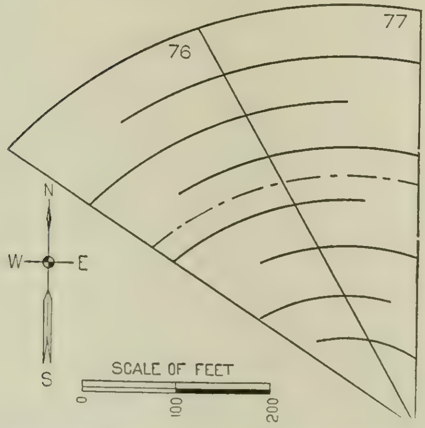

Fig. 5.—Diagram of Area A. The figures indicate positions of numbered stakes; broken arc, limit of area twice disked before seeding; continuous arcs, ridges approximately 50 feet apart to prevent run off of water.

AREA A.

This area, consisting of two triangular plats, Nos. 76 and 77, contains nearly 3 acres. The north half was twice disked parallel to the north line, the remainder being disked but once. The seed was then sown and covered with a harrow drawn parallel to the railway fence. The seed sown was a mixture of various remnants from other plats, as follows:

Plat 76.—Agropyron tenerum, Chloris elegans, Bouteloua oligostachya, Sporobolus airoides, Elymus canadensis, Eriocoma cuspidata, Sporobolus cryptandrus, Agropyron occidentale, and *Phaseolus rutusus.*

Plat 77.—Andropogon saccharoides, Chloris elegans, and *Bouteloua oligostachya.*

AREA B.

This area extends directly east and west, contiguous to the south side of Area C. No seed whatever was sown here, it being intended to determine what effect scarifying the surface would have on the development of native vegetation. A fine-tooth harrow was drawn over the area in an east and west direction.

AREA D.

This space is 200 feet in width and located between C and E. No seed was sown and no cultural operations performed. The object in laying out the ground in this way, with an uncultivated and unseeded strip between two cultivated and seeded ones, was to determine, should the seeded plats prove successful, whether the grasses sown would spread naturally over unseeded areas.

The cultural operations are vastly more simple than those usually employed in the grass investigations conducted by the Division. This is necessarily so because improvement of the range at the least possible expense is the desideratum here, and not the growing of the greatest amount possible per acre. The production of forage is so small here, at best, that one is obliged to measure his pasture by square miles rather than by acres, and the operations in range improvement must be on a correspondingly large scale. It has been deemed wise, therefore, to operate simply, but on comparatively large areas. The only implements used are disk harrows and fine-tooth harrows. Every possible combination of these has been used. In some cases the seed was sown directly on the mesa, with no previous preparation of the soil; in others, disking or harrowing preceded planting. In all cases the seed was covered by disking or harrowing, or by both combined. As far as possible all cultural operations extended lengthwise of the long strips, and therefore diagonally across the washes. The gangs of the disk harrow were set so as to ridge up the ground as much as possible. This method spreads the run-off of water over more land, and the ridged condition holds it to a greater extent than any other method would do.

A small grass garden has been started on the university grounds, in which nearly all of the varieties sown on the reservation have been planted in small quantities. Here moderate irrigation is practiced. One of the objects of this garden is to form a check upon the seeded plats on the reservation.

Owing to the diversity of climatic and soil conditions which obtain in southern Arizona, it has been thought wise to extend operations over a greater variety of territory than would be possible in the immediate vicinity of the University. Consequently aplan was inaugurated to cooperate in the matter of range improvement with farmers and ranchers who were located in favorable situations. Aside from the work performed directly by your agent, experiments are being conducted at eight other stations in the southern part of the Territory. In all of these cases those interested are doing the work with seed distributed from the station. The names and addresses of the ranchers who are performing experiments according to this plan are as follows:

M. R. Wise, Calabasas.
C. H. Baylis, Oracle.
H. C. Hooker, Wilcox.
Mr. Prince, Tucson.
Ozro Haskin, Tucson.
F. O. Benedict, Tucson.
W. M. Marteny, Arivaca.
W. B. McCleary, Helvetia.

Operations on the ranch of Col. H. C. Hooker are a little more extensive than in other instances. Your agent made a trip to the ranch in the latter part of February for the purpose of starting the work. Six small plats, aggregating about an acre of land, were sown to eight species of forage plants.

PRECIPITATION RECORDS.

In connection with the range improvement experiments, five precipitation records are being taken, in order to determine to what extent local variation in this particular obtains. Observations thus far conducted point to some very interesting conclusions, but they have not yet been continued long enough to enable one to generalize. The gauges are located as follows: Four miles north of the University; range reserve tract; Mescal; McCleary's camp; and 4 or 5 miles above McCleary's camp, in the Santa Rita Mountains. The first two are being attended to by the writer, the third by Mr. J. Ribail, and the latter two by Mr. W. B. McCleary. These, together with the record kept on the university grounds, give six readings, which will throw some light on our investigations.

SUMMARY AND SUGGESTIONS.

1. It being evident that the present unproductive condition of the range is due in the greatest measure to overstocking, it is desirable that some form of control of our public lands be devised whereby this practice, inevitable under present conditions, will be discontinued. How this desirable end may be reached does not appear clear, but it is evident that laws for the proper control and preservation of the ranges are essential, not only to the stock-growing interests, but also to the general welfare of the region, that the rains may be better conserved and prevented from disfiguring the surface of the country to an extent absolutely beyond the conception of anyone who has not had experience with these easily eroded Southwestern soils. The matter is of as much importance to the irrigation farmer as to the stockman himself, for the gullying of river channels during recent years and the cutting

of deep gorges in every depression, thereby destroying the tillable soils, are directly traceable to the influence of close grazing.

2. Just control, based on a system of land rentals which properly recognizes the rights of all ranchers located on the public ranges, would, it is believed, meet with popular approval and beneficial results.

3. The perennial grasses have been completely destroyed on large portions of the range. With absolute rest these areas would probably be reseeded in time, but it is believed that much can be done to expedite the matter by collecting seeds of native perennial forage plants in regions where they still persist and sowing them in the more favored localities of the denuded range. As far as the experiments which have been conducted indicate, the blue grama (*Bouteloua oligostachya*) and the Australian saltbush (*Atriplex semibaccata*) are the most promising for this purpose. *Bromus polyanthus paniculatus*, wire bunch grass (*Agropyron spicatum*), slender wheat grass (*Agropyron tenerum*), and shad scale (*Atriplex canescens*) also appear to be of some value for this purpose. It is impossible, however, to make definite recommendations at this time.

4. It is very necessary to test the germination qualities of native seeds. The grass garden started on the University grounds has served a useful purpose in this respect. The fact that native seed do not germinate when planted does not indicate that the species may not be a valuable one for reseeding worn-out range pastures, for it often occurs that native seed for various reasons does not germinate well. It is suspected that some of the seed gathered last season was not mature. This fault is often unavoidable, either on account of the methods of fruiting of the plant or on account of the collector's lack of time to wait for maturity.

5. Experiments thus far conducted in reseeding the worn-out mesa pastures having been begun in the month of January, it is desirable that subsequent experiments be carried on during or just before the summer rains. July or November will probably prove to be the best months for planting in this locality.

6. Judging from the season of 1900, grass seed can be most advantageously collected in the month of October. Seed of the native salt bushes can be gathered at any time from October to January.

7. On account of the excessive erosion careful attention should be paid to all cultural operations, and implements should be drawn in such a way that the rainfall may be held and spread over as much land as possible. In other words, cultural operations which extend diagonally across the drainage will usually prove most beneficial.

8. Fifty-two acres of the fenced portion of the reservation are under cultivation. This area is divided into 60 plats, upon which have been sown about 40 species of forage plants.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN No. 5.

B. T. GALLOWAY, Chief of Bureau.

SEEDS AND PLANTS

IMPORTED THROUGH THE SECTION OF SEED AND PLANT INTRODUCTION FOR DISTRIBUTION IN COOPERATION WITH THE AGRICULTURAL EXPERIMENT STATIONS.

INVENTORY No. 9.
NUMBERS 4351-5500.

Issued January 18, 1902.

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GOVERNMENT PRINTING OFFICE.
1902.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., September 10, 1901.

SIR: I have the honor to transmit herewith the manuscript of an inventory of seeds and plants imported for distribution in cooperation with the agricultural experiment stations. Many of these importations have proved to be of great value to the agricultural industries of the United States. Attention is called to the introductory statement (p. 5) for information regarding the distribution of the seeds and plants listed.

I recommend the publication of this manuscript as Bulletin No. 5 of the Bureau series.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

B. P. I—7. S. P. I—23.

INVENTORY OF FOREIGN SEEDS AND PLANTS.

INTRODUCTORY STATEMENT.

This inventory or catalogue of seeds and plants received during the spring and summer of 1900 represents the collections of the agricultural explorers of the Department of Agriculture in foreign countries, and also the receipts from various other sources. Included in the list are the seeds of a large number of native plants obtained for exchange with botanists and horticulturists abroad, it being possible to secure in this manner many valuable seeds and plants not for sale by dealers.

An effort has been made to verify every name, but in many cases the only sources of information have been the persons from whom the seeds or plants were obtained, while in some cases only colloquial names were obtainable. It is probable, therefore, that some of the names will be found to be incorrect.

The publication of this list has been so long delayed that many of the numbers are already entirely exhausted, as indicated by the word "Distributed," and many others will probably be distributed before this inventory reaches the experimenters.

The supply of seeds and plants at the disposal of this office is in most cases quite limited, inasmuch as the importations are made for experimental purposes and not for general distribution, it being unwise to make the latter until the value of the plants distributed is known. Distribution of the plants here catalogued will be confined almost entirely to the agricultural experiment stations and to persons known to be careful and reliable experimenters. It must not be expected that all or even the greater part of the importations will prove valuable. However, it is important that records not only of successes but of failures be obtained in order that future work may be more successful.

It is especially desirable that all persons receiving seeds or plants should retain the original numbers marked on the packages, as all the reports or other information will be filed under these numbers, and in this way be easy of access.

Ernst A. Bessey,
Assistant in Charge of Seed and Plant Introduction.

INVENTORY.

4351. VICIA FABA. **Broad bean.**

From Naples, Italy. Received February 5, 1900.

Aguadulce, improved. A fine bean with pods 2 inches wide and 14 to 16 inches long, but few-seeded and with only three or four well-grown pods on each plant.

4352. VICIA FABA. **Broad bean.**

From Naples, Italy. Received February 5, 1900.

Sevilla Long Pod. "Stem quadrangular, erect, 2 to 2½ feet high, not very stout, green or slightly tinged with red; foliage light green; flowers one or two to four in each cluster. The standard is greenish white, longer than broad, and remains folded in the center even when the flower is in full bloom. The first cluster of flowers usually appears in the axil of the seventh leaf from the base of the stem. The pods are about one-half inch wide and 8 to 12 inches long, solitary or in pairs, and soon become pendent by their weight. An early variety, but not very hardy." (*Vilmorin.*)

4353. VICIA FABA. **Broad bean.**

From Naples, Italy. Received February 5, 1900.

Sicilian. A purple-seeded variety, smaller and less productive than the field bean.

4354. VICIA FABA. **Broad bean.**

From Naples, Italy. Received February 5, 1900.

Neapolitan.

4355. BRASSICA OLERACEA BOTRYTIS. **Broccoli.**

From Naples, Italy. Received February 5, 1900.

Purple Navidad. Early, dark purple.

4356. BRASSICA OLERACEA BOTRYTIS. **Broccoli.**

From Naples, Italy. Received February 5, 1900.

Santa Teresa. "Early, purple, changing to green when cooked." (*Dammann.*)

4357. BRASSICA OLERACEA BOTRYTIS. **Broccoli.**

From Naples Italy. Received February 5, 1900.

White San Isidor.

4358. BRASSICA OLERACEA BOTRYTIS. **Broccoli.**

From Naples, Italy. Received February 5, 1900.

San Martinari. A purplish variety, which ripens in Italy in November.

4359. BRASSICA OLERACEA BOTRYTIS. **Broccoli.**

From Naples, Italy. Received February 5, 1900.

Gennarese. A purplish variety, maturing in Italy in January.

4360. CICHORIUM INTYBUS. **Chicory.**

From Naples, Italy. Received February 5, 1900.

Asparagus. A variety which produces rosettes of much-thickened leaves. These are cooked and served cold, and are said to be delicious in salads.

4361. BETA VULGARIS. **Chard.**

From Naples, Italy. Received February 5, 1900.

Swiss Silver-ribbed. "A fine sort, with large, wide leaves, which are very wavy, half-erect, and remarkable for the size of their stalks and midribs, which are often 4 inches or more in width. Quite productive and of very good quality, with a delicate, slightly acidulous flavor. The leaves may also be used for greens, the lighter-colored ones being the best for this purpose. Chards sown in early spring commence to mature their stalks in July and continue well into the winter." (*Vilmorin.*) Distributed.

4362. BETA VULGARIS. **Chard.**

From Naples, Italy. Received February 5, 1900.

Curled Silver-ribbed. Almost as prolific as No. 4361, with leaves equally white but remarkably crimped and curled. The leafstalks are narrower, but of quite as good quality.

4363. BETA VULGARIS. **Chard.**

From Naples, Italy. Received February 5, 1900.

Chilian Scarlet. A very large kind, with long, stiff, almost erect leafstalks 2 or 3 inches wide. Leaves rather large, 2 to 2½ feet long, wavy, almost curled, dark green, with a metallic luster. The leafstalks are bright red. Often grown as an ornamental plant.

4364. BETA VULGARIS. **Chard.**

From Naples, Italy. Received February 5, 1901.

Chilian Yellow. A very large kind, with long, stiff, almost erect leafstalks 2 or 3 inches wide. Leaves rather large, 2 to 2½ feet long, wavy, almost curled, dark green, with a metallic luster. The leafstalks are a deep yellow. Often used as an ornamental plant.

4365. CUCURBITA PEPO. **Vegetable marrow.**

From Naples, Italy. Received February 5, 1900.

4366. CUCURBITA PEPO. **Vegetable marrow.**

From Naples, Italy. Received February 5, 1900.

White Cocozella of Tripoli.

4367. FŒNICULUM DULCE. **Sweet fennel.**

From Naples, Italy. Received February 5, 1900.

Largest of Sicily. A new Italian variety.

4368. FŒNICULUM DULCE. **Sweet fennel.**

From Naples, Italy. Received February 5, 1900.

Prince Bismarck. Remarkable for the very much thickened leafstalks.

4369. FŒNICULUM DULCE. **Sweet fennel.**

From Naples, Italy. Received February 5, 1900.

Morosini. A variety originated by Dammann in 1896. The sweetest, best, and most tender variety known. In three months from the seed it forms very large, golden yellow stalks and bright green, finely divided leaves. An excellent market-gardener's variety.

4370. FŒNICULUM DULCE. **Sweet fennel.**

From Naples, Italy. Received February 5, 1900.

Bolognese.

4371. BOEHMERIA NIVEA. **Ramie.**

From Naples, Italy. Received February 5, 1900.

A perennial, native of eastern Asia, long grown in China and India. A fiber known as *China grass* is manufactured from the stems. Ramie requires a hot, moist climate, without extremes of temperature, and a rich, moist soil, so that growth shall be rapid and continuous during the season. The plant is propagated by seeds, cuttings, layers, and division of the roots. The seeds, when used, should be started in hotbeds and the beds shaded until the plants are 2 to 6 inches high, when they may be transplanted to the fields. The best method of propagation is by dividing the roots. The plant is ready for harvest when the seeds commence to ripen.

4372. CERATONIA SILIQUA. **Carob.**

From Naples, Italy. Received February 5, 1900.

St. John's Bread, or Algaroba. (See No. 3112, Inventory No. 7.)

4373. HOVENIA DULCIS. **Raisin tree.**

From Naples, Italy. Received February 5, 1900.

(See Nos. 3028 and 3310, Inventory No. 7.)

4374. NICOTIANA TABACUM. **Tobacco.**

From Naples, Italy. Received February 5, 1900.

Hungarian Debroë.

4375. NICOTIANA TABACUM. **Tobacco.**

From Naples, Italy. Received February 5, 1900.

Hungarian Czetneck.

4376. NICOTIANA TABACUM. **Tobacco.**

From Naples, Italy. Received February 5, 1900.

Hungarian Szegedin.

4377. VIGNA CATJANG. **Cowpea.**

From Naples, Italy. Received February 5, 1900, under the name of *Dolichos sphorospermus.*

4378. PACHYRHIZOS TUBEROSUS. **Yam-bean.**

From Naples, Italy. Received February 5, 1900.

"The yam-bean or ahipa is a native of Venezuela and other parts of South America up to elevated country. It climbs to a height of 20 feet and bears pods much larger than those of *P. angulatus,* which in a young state are used like French beans. When boiled they are tender and sweetish, but deleterious when raw. They are free from fibrous strings at the edge. Seeds variable in color. The tubers of three plants may fill a bushel basket. They mature in a few months. These edible tubers may attain a weight of 60 pounds." (*Von Mueller.*)

4379. VIGNA CATJANG. **Cowpea.**

From Naples, Italy. Received February 5, 1900, under the name of *Dolichos lubia.*

4380. DOLICHOS LABLAB. **Madagascar bean.**

From Naples, Italy. Received February 5, 1900.

4381. VIGNA CATJANG. **Cowpea.**

From Naples, Italy. Received February 5, 1900, under the name of *Dolichos bahiensis.*

4382. VIGNA CATJANG. **Cowpea.**

From Naples, Italy. Received February 5, 1900, under the name of *Dolichos bicontortus.*

4383. DOLICHOS ATROPURPUREUS.

From Naples, Italy. Received February 5, 1900.

4384. DOLICHOS SEMPERVIRENS.

From Naples, Italy. Received February 5, 1900.

4385. PHASEOLUS CARACALLA.

From Naples, Italy. Received February 5, 1900.

4386. PANICUM TEXANUM. **Colorado grass.**

From Fort Worth, Tex. Received February 5, 1900.

(This seed was destroyed because of its low germination.)

4387. ZEA MAYS. **Corn.**

From Texas. Received February 7, 1900.

Mexican June. This variety is much used in Mexico and southern Texas for late planting. In the southern half of the Gulf States it can be successfully grown after a crop of oats, millet, or wheat has been harvested. It is a white corn and the ears are of a good size, each stalk producing from one to three ears. The stalks attain a height of from 10 to 15 feet. The blades are more numerous than on most other varieties, making this valuable for forage or ensilage purposes. It is often planted between rows of Irish potatoes and other truck, and is suitable for rich bottom lands that become dry enough to plant early in June.

4388. MIMUSOPS BALATA. **Balata.**

From Georgetown, British Guiana. Received February 7, 1900, from John Guillat.

This tree is the source of the balata gum of commerce, a substance closely resembling guttapercha, and substituted for it in many manufactures. It is a native of tropical South America. Distributed.

4389. CUCUMIS MELO. **Winter muskmelon.**

From California. Received February 8, 1900. Presented by Ira W. Adams, of Calistoga, Cal.

"The seed of this valuable melon was procured by Dr. J. D. B. Stillman, at Smyrna, in 1879. It came from the city of Cassaba, in Asia Minor, a city celebrated for the fine quality of its melons. I found them to be the sweetest, spiciest, and most delicious melons I ever ate. I could compare them to nothing else I ever ate in the fruit line, unless it was to a ripe, luscious pineapple. I kept one of these melons through the winter of 1885, until April 3; it was then fully ripe and very delicious. They should be planted the same as other muskmelons and picked after the frost has killed the vines or nipped them pretty badly. Light frosts do not harm them in the least. Cut off the stem quite close to the melon and handle carefully, putting them in the coolest and dryest place you have. If stored in a warm room they ripen very rapidly, and will be gone before the winter fairly sets in. This melon, unlike any other I have ever seen, when cut from the vine is very hard, especially two-thirds of it from the stem end, and quite rough and deeply corrugated, deflecting, however, very much from a straight line. The rind is of a grayish-green color, and can scarcely be indented with the thumb nail. The flesh is a creamy green and very thick and firm. When fully ripe most of them turn a little yellow, some quite yellow, and a spot on the blossom end about the size of a half dollar will be found quite mellow on pressing it. This is an infallible test, and you may be sure the melon is fit to eat, notwithstanding it may still look green, and most of the rind may yet remain very hard. They are excellent feed for milch cows, calves, horses, and poultry. The average weight for salable melons is from 6 to 10 pounds, although I have raised a great many that weighed 12 to 15 pounds each, and one that weighed 19½ pounds. I have had these melons in my yard entirely exposed to the weather when the temperature was down to 32° and 30° above zero, without being harmed in the least. I plant the seeds of this melon here from the 1st to the 10th of May, in hills 6 feet apart each way, leaving finally two plants in a hill. I cultivate them thoroughly, once a week both ways, until the vines interfere." (*Adams.*) Distributed.

4390. ZEA MAYS. **Corn.**

From Tennessee. Received February 8, 1900.

Wellborn's Conscience. Seed destroyed.

4391. AVENA SATIVA. **Oat.**

From North Dakota. Received February 1, 1900.

White Russian. This is a very hardy oat, prolific and of excellent quality. It is admirably adapted for cultivation in the coldest latitudes of this country, having originated in a similar climate. It is about the most resistant to crown rust of all northern-grown varieties. Should be sown very early—as soon as the opening of spring will permit.

4392. TRITICUM COMPACTUM. **Wheat.**

From Idaho. Received February, 1900.

Little Club. This variety is one of the club group of wheats, and is commonly grown in Washington, Idaho, and Oregon. It may be sown in autumn or spring. The plant is short, with short but very compact, beardless heads, well filled. The grain is white, soft and starchy, rounded, and pointed, somewhat similar in shape to barley grains. It is adapted admirably to all Northwestern mountain States, but might also be tried in the more southern States if sown in October.

4393. ZEA MAYS. **Corn.**

From South Carolina. Received February, 1900.

Garick's Prolific. A white field corn with medium ears. Stalks stout, leafy, bearing two to five ears, which finally become pendent. An excellent variety for the South.

4394. MEDICAGO SATIVA. **Alfalfa.**

From northern Utah. Received February 8, 1900. Distributed.

4395. MEDICAGO SATIVA. **Alfalfa.**

From southern Utah. Received February 8, 1900. Distributed.

4396. PHLEUM PRATENSE. **Timothy.**

From Utah. Received February 8, 1900.

4397. LANDOLPHIA HENDELOTII.

From France. Received February 10, 1900.

The *Landolphias* are African rubber plants. They are lianes or vines. Recent experiments indicate that all of the caoutchouc in the plant may be extracted by mechanical means, the stems being first dried and then macerated in warm water. Distributed.

4398. LANDOLPHIA KLEINII.

From France. Received February 10, 1900.

(See No. 4397.) Distributed.

4399. FICUS ELASTICA. **Assam rubber.**

From France. Received February 14, 1900.

"Assam rubber comes mostly from *Ficus elastica.* A little of it is derived from *Urostigma laccifera.* *Ficus elastica* grows in the hot mountain valleys of the Himalayas, between 70° and 80° east longitude, where the air remains warm and damp and the mercury stands at 38° C. in the shade." (*Semmler.*) Distributed.

4400. FICUS RELIGIOSA. **Fig of Scripture.**

From France. Received February 14, 1900.

Somewhat similar to No. 4399 in that it is the source of a commercial rubber in the East Indies. Distributed.

4401. PITHECOLOBIUM SAMAN. **Rain tree.**

From France. Received February 14, 1900.

Inga Saman. The pods of this West Indian tree are useful for forage, resembling those of the mesquite bean. The tree has been recommended as a nurse tree in banana or coffee plantations. (See No. 2724, Inventory No. 7.)

4402. BETA VULGARIS. **Sugar beet.**

From Germany. Presented by Mr. Ad. Strandes, of Rittergut, Zehringen bei Cöthen. Received February 15, 1900.

Zehringen Elite, from polarized mother beets. Distributed.

4403. ZEA MAYS. **Sugar corn.**

From New York. Received February 14, 1900.

Stowell's Evergreen.

4404. TRITICUM VULGARE. **Wheat.**

From Minnesota. Received February 16, 1900.

Wellman's Fife. An improved strain of the "Saskatchewan" and further improved through rigid seed selection by Mr. D. L. Wellman, of Frazee City, Minn. Claimed to be particularly hardy, productive, and rust-resistant. A bald variety with medium-sized hard, red grains. Should be sown as early in the spring as the weather will permit. Adapted to all Northern spring-wheat districts.

4405. ANDROPOGON SORGHUM. **Sorghum.**

From Missouri. Received February 15, 1900. Presented by Mr. W. P. Griffin, of Altamont.

An improved variety, originated by Mr. Griffin. It is better adapted for sirup than the Amber cane, because the juice does not granulate so readily. The cane is stout, erect, firmly rooted. It matures in 12 to 14 weeks, and is a heavy yielder both of juice and seed.

4406. AVENA SATIVA. **Oat.**

From Texas. Received February 13, 1900.

Texas Rust-proof. This prolific variety of red oat is very popular in Texas and other portions of the Southern States, particularly because of its rust-resisting qualities, as the oat crop in that region is often ruined by rust if ordinary varieties are sown. It should be sown in the fall or early in the spring. It is one of the best varieties for the South.

4407. AVENA SATIVA. **Oat.**

From Rock West, Ala. Received February 15, 1900.

Ninety Day. An early-maturing oat. Presented by Mr. W. P. Murphy.

4408. TRIFOLIUM ALPINUM. **Clover.**

From Grenoble, France. Received February 15, 1900.

This clover was one of the most promising sorts grown in the Alpine grass garden at Grenoble.

4409–4413. LAGENARIA VULGARIS. **Gourd.**

From Naples, Italy. Received February 19, 1900.

A collection of ornamental gourds useful for trellis work:

4409. LAGENARIA VULGARIS DEPRESSA.

4410. LAGENARIA VULGARIS MAXIMA.

4411. LAGENARIA VULGARIS LONGISSIMA.

4412. LAGENARIA VULGARIS.

4413. LAGENARIA VULGARIS, *Pulverhorn.*

4414. CAPRIOLA DACTYLON. **Bermuda grass.**

From Australia. Received February 18, 1900.

4415. PINUS. **Pine.**

From Syria. Presented by Mr. W. Michael, of Congo, Ky. Received February 24, 1900.

A pine from the slopes of Mount Lebanon.

4416. BETA VULGARIS. **Sugar beet.**

From Proskurow, Russia. Received through Dr. Mrozinski, February 27, 1900.

Kleinwanzlebener (*Mrozinski, No. 2, Russia*). Seed from beets grown on clayey black prairie soil. (See No. 3941, Inventory No. 8.) Distributed.

4417. BROMUS INERMIS. **Smooth brome grass.**

From Portland, Oreg. Received March, 1900.

Oregon-grown seed. (See No. 2964, Inventory No. 7.) Distributed.

4418. BROMUS INERMIS. **Smooth brome grass.**

From Portland, Oreg. Received February 28, 1900.

Seed grown in the vicinity of Spokane, Wash. (See No. 2964, Inventory No. 7.) Distributed.

4419. BROMUS INERMIS. **Smooth brome grass.**

From Toronto, Canada. Received February 28, 1900.

Seed grown in Assiniboia, Northwest Territory, Canada. (See No. 2964, Inventory No. 7.) Distributed.

4420. BROMUS INERMIS. **Smooth brome grass.**

From Manitoba. Received March, 1900.

Seed grown in Manitoba, Canada. (See No. 2964, Inventory No. 7.) Distributed.

4421. NICOTIANA TABACUM. **Tobacco.**

From Naples, Italy. Received February 26, 1900.

Sumatra.

4422. NICOTIANA TABACUM. **Tobacco**

From Naples, Italy. Received February 26, 1900.

Brazilian.

4423. COVILLEA DIVARICATA. **Greasewood.**

From Tucson, Ariz. Received through Mr. W. T. Swingle, December, 1899.

4424. PROSOPIS VELUTINA? **Mesquite.**

From Tucson, Ariz. Received through Mr. W. T. Swingle, November, 1899.

4425. PROSOPIS VELUTINA? **Mesquite.**

From Tuscon, Ariz. Received through Mr. W. T. Swingle, November, 1899.

4426. VITIS ARIZONICA.

From Tucson, Ariz. Received through Mr. W. T. Swingle, December, 1899.

4427. ZIZYPHUS LYCIOIDES.

From Arizona. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4428.

From Benson, Ariz. Received through Mr. W. T. Swingle, November, 1899. Distributed.

4429. LYCIUM ERICOIDES.

From Benson, Ariz. Received through Mr. W. T. Swingle, December, 1899.

4430. ECHINOCACTUS WISLIZENI. **Visnaga.**

From Benson, Ariz. Received through Mr. W. T. Swingle, December, 1899.

4431. SESBANIA MACROCARPA.

From Yuma, Ariz. Received through Mr. W. T. Swingle, November, 1899.

4432. ATRIPLEX CANESCENS.

From Yuma, Ariz. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4433. PARKINSONIA TORREYANA. **Palo verde.**

From Yuma, Ariz. Received through Mr. W. T. Swingle, November, 1899. Distributed.

4434. HOLACANTHA EMORYI.

From Maricopa, Ariz. Received through Mr. W. T. Swingle, December, 1899.

4435. PROSOPIS JULIFLORA? **Mesquite.**

From Tempe, Ariz. Received through Mr. W. T. Swingle, November, 1899. Distributed.

4436. PROSOPIS PUBESCENS? **Mesquite.**

From California, near Yuma, Ariz. Received through Mr. W. T. Swingle, November, 1899.

4437. ATRIPLEX LENTIFORMIS.

From California, near Yuma, Ariz. Received through Mr. W. T. Swingle, November, 1899.

4438. ASCLEPIAS SUBULATA.

From California. Received through Mr. W. T. Swingle, November, 1899.

4439. ATRIPLEX LENTIFORMIS.

From California, near Yuma, Ariz. Received through Mr. W. T. Swingle, November, 1899. Distributed.

4440. CUCUMIS MELO. **Muskmelon.**

From Applegate, Cal. Presented by Col. John P. Irish, through Mr. W. T. Swingle, October, 1899.

4441. MEDICAGO LUPULINA.

From Applegate, Cal. Received through Mr. W. T. Swingle, October, 1899.

4442. TRICHOSTEMA LANCEOLATUM.

From Applegate, Cal. Received through Mr. W. T. Swingle, October, 1899. Distributed.

4443. LOTUS SERICEUS.

From Applegate, Cal. Received through Mr. W. T. Swingle, October, 1899. Distributed.

4444. LUPINUS ARBOREUS.

From San Francisco, Cal. Received through Mr. W. T. Swingle, November, 1899.

4445. LINUM GRANDIFLORUM.

From Berkeley, Cal. Received through Mr. W. T. Swingle, October, 1899.

4446. LUPINUS DENSIFLORUS.

From Hornbrook, Cal. Received through Mr. W. T. Swingle, October, 1899.

4447. YUCCA WHIPPLEI.

From Los Angeles, Cal. Received through Mr. W. T. Swingle, November, 1899.

4448. SCHINUS MOLLE. **Pepper tree.**

From California. Received through Mr. W. T. Swingle, October, 1899.

4449. VITIS CALIFORNICA.

From Sacramento, Cal. Received through Mr. W. T. Swingle, October, 1899. Distributed.

4450. ROBINIA NEO-MEXICANA.

From California. Received through Mr. W. T. Swingle, October, 1899.

4451. FOUQUIERIA SPLENDENS. **Ocatillo.**

From California, opposite Yuma, Ariz. Received through Mr. W. T. Swingle, November, 1899. Distributed.

4452. PLATANUS RACEMOSA.

From Santa Barbara, Cal. Received through Mr. W. T. Swingle, November, 1899.

4453. PHASEOLUS VULGARIS. **Bean.**

From Applegate, Cal. Presented by Col. John P. Irish, through Mr. W. T. Swingle, October, 1899. Distributed.

Frijole Romana.

4454. GILIA AGGREGATA.

From Spokane Falls, Wash. Received through Mr. W. T. Swingle, September, 1899. Distributed.

4455. BROMUS PORTERI.

From Pullman, Wash. Received through Mr. W. T. Swingle, September, 1899. Distributed.

4456. RUMEX HYMENOSEPALUS. **Canaigre.**

From Tempe, Ariz. Received through Mr. W. T. Swingle, November, 1899. Distributed.

4457. GAULTHERIA SHALLON.

From Seattle, Wash. Received through Mr. W. T. Swingle, October, 1899.

4458. MAMMILLARIA GRAHAMI.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4459. CRATÆGUS.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4460. VALLESIA GLABRA.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1889.

4461. PERITYLE LEPTOGLOSSA.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4462. MARTYNIA FRAGRANS.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4463. STEGNOSPERMA HALIMIFOLIA.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4464. ASCLEPIAS SUBULATA.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4465. PARKINSONIA ACULEATA. **Vagote.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4466. NISSOLIA SCHOTTII.

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4467. COUTAREA LATIFOLIA.

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4468. ACACIA FILICULOIDES.

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4469. PARKINSONIA. **Palo verde.**

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4470. FOUQUIERIA. **Ocatillo.**

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4471. CÆSALPINIA GRACILIS.

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4472. CEREUS THURBERI. **Pitahaya.**

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4473. CEREUS PECTEN-ABORIGINUM.

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4474. GOSSYPIUM BARBADENSE. **Sea-island cotton.**

From James Island, South Carolina. Received February 28, 1900, through the Division of Vegetable Physiology and Pathology. Presented by Mr. F. P. Seabrook.

This is one of the best varieties of sea-island cotton.

4475. DAHLIA VARIABILIS. **Dahlia.**

From Naples, Italy. Received through Wulle & Co., February 28, 1900.

Dahlia excelsior fantasia. Distributed.

4476. DAHLIA VARIABILIS. **Dahlia.**

From Naples, Italy. Received through Wulle & Co., February 28, 1900.

Dahlia variabilis Imperialis.

4477. HELIOTROPIUM INCANUM. **Heliotrope.**

From Naples, Italy. Received through Wulle & Co., February 28, 1900.

Non plus ultra. Distributed.

4478. TORENIA FOURNIERI. **Torenia.**

From Naples, Italy. Received through Wulle & Co., February 28, 1900.

Princess Helena of Montenegro. Torenia with giant flowers. Distributed.

4479. TORENIA FOURNIERI. **Torenia.**

From Naples, Italy. Presented by Wulle & Co., February 28, 1900.

The Bride. Distributed.

4480. IPOMŒA COLLATA.

From Naples, Italy. Received February 28, 1900.

Ipomoe collata cinerea. A very delicately colored new hybrid with corolla irregular like the Japanese sorts.

4481. IPOMŒA LEARI.

From Naples, Italy. Received February 28, 1900.

Ipomœa leari perenne splendida. A remarkably rapid grower; very showy.

4482. BRASSICA OLERACEA BOTRYTIS. **Broccoli.**

From Naples, Italy. Received through Wulle & Co., February 28, 1900.

Early Violet. Ripens in January. A spring and summer vegetable, like cauliflower, but with green heads.

4483. BRASSICA OLERACEA BOTRYTIS. **Broccoli.**

From Naples, Italy. Received February 28, 1900.

Febralino. Ripens in February. A spring and summer vegetable, like cauliflower, but with green heads.

4484. FŒNICULUM DULCE. **Sweet fennel.**

From Naples, Italy. Received February 28, 1900.

Doux de Boulogne. An excellent vegetable, which deserves trial by American gardeners.

4485. FŒNICULUM DULCE. **Sweet fennel.**

From Naples, Italy. Received February 28, 1900.

Doux de Messina. (See No. 4484.)

4486. LACTUCA SATIVA. **Lettuce.**

From Naples, Italy. Received February 28, 1900.

Scarlet Genezzano. "A black-seeded variety; head very hard, brown, but yellow inside. It lasts a long time and withstands the highest temperatures and drought. Worthy of trial in all arid and semiarid regions." (*Fairchild.*)

4487. ALLIUM CEPA. **Onion.**

From Naples, Italy. Received February 28, 1900.

Tripoli Barletta Wonder. A small, very early white variety.

4488. ALLIUM CEPA. **Onion.**

From Naples, Italy. Received February 28, 1900.

Silver-white Nocera.

4489. ALLIUM CEPA. **Onion.**

From Naples, Italy. Received February 28, 1900.

Giant Rocca. Blood red.

4490. ALLIUM CEPA. **Onion.**

From Naples, Italy. Received February 28, 1900.

Bassano. Dark red.

4491. LYCOPERSICUM ESCULENTUM. **Tomato.**

From Naples, Italy. Received February 28, 1900.

Prince Bismarck. "A larger fruit than the *Peach* tomato, with yellow skin. A seedling from the *Peach,* but differing from it in color." (*Fairchild.*)

4492–4498. LAGENARIA VULGARIS. **Gourd.**

From Naples, Italy. Received February 28, 1900.

A collection of the so-called *Zuccini.* The immature fruits are cooked like vegetable marrow or summer squash. These are worthy a trial. They are as follows:

4492. CLAVATA. A club-shaped gourd.
4493. DEPRESSA.
4494. CANTEEN.
4495. BOTTLE.
4496. MINIMA. Dwarf.
4497. POWDERHORN.
4498. MIXED.

4499. LUPINUS ARBOREUS.

From Berkeley, Cal. Received through Mr. W. T. Swingle, January, 1900. Distributed.

4500. FOUQUIERIA SPINOSA? **Ocatillo.**

From Moreno, Mexico. Received through Mr. W. T. Swingle, December 16, 1899.

4501. RANDIA THURBERI.

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4502. ACACIA?

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4503. ANTIGONON LEPTOPUS.

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4504. BURSERA MICROPHYLLA. **Torrote blanco.**

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4505. CEREUS PECTEN-ABORIGINUM?

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4506. PARKINSONIA. **Palo verde.**

From Moreno, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4507. HIRÆA SEPTENTRIONALIS. **Gallinito.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4508. CALOPHANES PENINSULARIS.

From Guaymas, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4509. HÆMATOXYLON BOREALE.

From Guaymas, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4510. PITHECOLOBIUM SONORÆ.

From Guaymas, Mexico. Received through Mr. W. T. Swingle, December, 1899)

4511. POINCIANA REGIA. **Árbol de fuego.**

From Guaymas, Mexico. Presented by Señor Bustamante, through Mr. W. T. Swingle, December, 1899.

4512. FICUS FASCICULATA.

From Guaymas, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4513. LORANTHUS.

From Guaymas, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4514. ECHINOCACTUS.

From Guaymas, Mexico. Received through Mr. W. T. Swingle, December, 1899

4515. BEBBIA JUNCEA.

From Guaymas, Mexico. Received through W. T. Swingle, December, 1899.

4516. DIOSPYROS. **Guayparin.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4517. PARKINSONIA ACULEATA. **Vagote.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4518. NICOTIANA GLAUCA.

From San Juan, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4519. BURSERA MICROPHYLLA.

From Guaymas, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4520. CRESCENTIA ALATA. **Ayal.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4521. PITHECOLOBIUM DULCE. **Guaymochil.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4522. CARTHAMUS TINCTORIUS. **Safflower.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4523. ABRUS PRECATORIUS.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4524. QUERCUS EMORYI.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4525. MARTYNIA PROBOSCIDEA.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4526. CAPSICUM ANNUUM. **Red pepper.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

Chipotle.

4527. CAPSICUM ANNUUM. **Red pepper.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

Chile ancho.

4528. CAPSICUM. **Red pepper.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

Chile pasilla or *C. piasia?*

4529. CAPSICUM FRUTESCENS BACCATUM. **Bird pepper.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

Chiltipines.

4530. CAPSICUM ANNUUM. **Red pepper.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

Chile colorado.

4531. CAPSICUM ANNUUM. **Red pepper.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

Chile costeño.

4532. SIMMONDSIA CALIFORNICA. **Jojoba.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4533. PITHECOLOBIUM DULCE. **Guaymochil.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4534. SALVIA COLUMBARIÆ. **Chia.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle.

4535.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4536. PINUS EDULIS? **Piñon.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4537. OLNEYA TESOTA.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

4538. TAMARINDUS INDICA. **Tamarind.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4539. CEREUS SCHOTTII.

From Tucson, Ariz. Presented by Prof. J. W. Toumey, through Mr. W. T. Swingle, December, 1899. Distributed.

4540. ACACIA LONGIFOLIA.

From Oakland, Cal. Received through Mr. W. T. Swingle, December, 1899.

4541. ZIZYPHUS? **Chinese date.**

From San Francisco, Cal. Received through Mr. W. T. Swingle, October, 1899.

4542. SYMPHORICARPOS RACEMOSUS. **Snowberry.**

From Pullman, Wash. Received through Mr. W. T. Swingle, September, 1899. Distributed.

4543. RIBES DIVARICATUM?

From Seattle, Wash. Received through Mr. W. T. Swingle, October, 1899.

4544. HUMULUS LUPULUS. **Hop.**

From Puyallup, Wash. Received through Mr. W. T. Swingle, October, 1899. Distributed.

Cluster Hop.

4545. BROMUS VULGARIS EXIMIUS.

From Seattle, Wash. Received through Mr. W. T. Swingle, October, 1899. Distributed.

4546. CHAMÆNERION ANGUSTIFOLIUM. **Fireweed.**

From Madroña Park, Seattle, Wash. Received through Mr. W. T. Swingle, October, 1899. Distributed.

4547. ANAPHALIS MARGARITACEA. **Everlasting.**

From Seattle, Wash. Received through Mr. W. T. Swingle, October, 1899. Distributed.

4548. **"Lo han qua."**

From San Francisco, Cal. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4549. CEPHALANTHUS OCCIDENTALIS. **Button-bush.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

4550. PANICUM VIRGATUM.

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4551. POLYGONUM DUMETORUM SCANDENS.

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4552. AMORPHA FRUTICOSA. **False indigo.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4553. HUMULUS LUPULUS. **Wild hop.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4554. LIATRIS PUNCTATA. **Blazing-star.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4555. CELTIS OCCIDENTALIS. **Hackberry.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

4556. CELTIS OCCIDENTALIS. **Hackberry.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

4557. PLATANUS OCCIDENTALIS. **Plane tree.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

4558. RHUS GLABRA. **Sumac.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

4559. CERCIS CANADENSIS. **Red bud.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4560. CERCIS CANADENSIS. **Red bud.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4561. RHUS GLABRA. **Sumac.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

4562. GLEDITSIA TRIACANTHOS. **Honey locust.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

From a nearly thornless tree. Distributed.

4563. GLEDITSIA TRIACANTHOS. **Honey locust.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

From an entirely thornless tree. Distributed.

4564. GLEDITSIA TRIACANTHOS. **Honey locust.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

From a thorny tree. Distributed.

4565. CUCURBITA PEPO. **Vegetable marrow.**

From Westfield, Mass. Received through Mr. H. L. Loomis, March 1, 1900.

Originally from Honolulu. Distributed.

4566. ERIOBOTRYA JAPONICA. **Loquat.**

From Sicily. Received through Messrs. Lathrop and Fairchild, March 5, 1900.

Palermo. A new variety originated by Dr. C. Sprenger, Vomero, Naples, Italy. Distributed.

4567. ERIOBOTRYA JAPONICA. **Loquat.**

From Sicily. Received through Messrs. Lathrop and Fairchild, March 5, 1900.

Limoncella. A new strain originated by Dr. C. Sprenger, Vomero, Naples, Italy. Distributed.

4568. ZEA MAYS. **Corn.**

From Kansas. Received March 6, 1900.

A yellow dent.

4569. ZEA MAYS. **Corn.**

From Kansas. Received March 6, 1900.

Roseland White.

4570. OPUNTIA FICUS-INDICA INERMIS. **Spineless cactus.**

From France. Received March 6, 1900.

This spineless pear cactus is extensively grown in Algeria for forage.

4571. PANICUM MILIACEUM. **Broom-corn millet.**

From Smrzicich, Moravia. Received from Frant. Vodicka, March 6, 1900.

This millet is one of the most important crops in many parts of Moravia.

4572. HORDEUM DISTICHUM NUTANS. **Barley.**

From Smrzicich, Moravia. Received from Frant. Vodicka, March 6, 1900.

Hanna. "A famous variety of barley for malting purposes. It is grown in the valley of the river Hanna, the richest part of Moravia." (*Dongres.*)

4573. PLATANUS OCCIDENTALIS. **Plane tree.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4574. GYMNOCLADUS CANADENSIS. **Kentucky coffee tree.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4575. GYMNOCLADUS CANADENSIS. **Kentucky coffee tree.**

From Manhattan, Kans. Received through Mr. W. T. Swingle, December, 1899.

4576. SCHRANKIA UNCINATA. **Sensitive briar.**

From Barton County, Kans. Presented by Mr. Albert Dickens, Kansas Agricultural Experiment Station. Received through Mr. W. T. Swingle, February, 1900.

4577. SPOROBOLUS AIROIDES. **Sacaton grass.**

From Benson, Ariz. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4578. SAPINDUS ACUMINATUS.

From Columbia, Tex. Received through Mr. B. F. Bush, February, 1900

Very handsome in cultivation.

4579. DODECATHEON MEADII.

From Swan, Mo. Received through Mr. B. F. Bush, February, 1900. Distributed.

4580. ECHINACEA ANGUSTIFOLIA.

From Lees Summit, Mo. Received through Mr. B. F. Bush, February, 1900.

4581. RHAMNUS LANCEOLATUS.

From Independence, Mo. Received through Mr. B. F. Bush, February, 1900. Distributed.

4582. RHUS AROMATICA.

From Swan, Mo. Received through Mr. B. F. Bush, February, 1900.

4583. ECHINACEA PURPUREA.

From Monteer, Mo. Received through Mr. B. F. Bush, February, 1900. Distributed.

4584. AGAVE VIRGINICA.

From Swan, Mo. Received through Mr. B. F. Bush, February, 1900. Distributed.

4585. CRATÆGUS VIRIDIS.

From Columbia, Tex. Received through Mr. B. F. Bush, February, 1900.

4586. SMILAX ROTUNDIFOLIA.

From Columbia, Tex. Received through Mr. B. F. Bush, February, 1900. Distributed.

4587. BUMELIA LYCIOIDES.

From Columbia, Tex. Received through Mr. B. F. Bush, February, 1900.

4588. CISSUS STANS.

From Columbia, Tex. Received through Mr. B. F. Bush, February, 1900. Distributed.

4589. BERCHEMIA SCANDENS.

From Swan, Mo. Received through Mr. B. F. Bush, February, 1900. Distributed.

4590. CRATÆGUS POPULIFOLIA.

From Swan, Mo. Received through Mr. B. F. Bush, February, 1900.

4591. CRATÆGUS ROTUNDIFOLIA.

From Swan, Mo. Received through Mr. B. F. Bush, February, 1900.

4592. CRATÆGUS COLLINA.

From Swan, Mo. Received through Mr. B. F. Bush, February, 1900.

4593. CRATÆGUS SACCHARINA.

From Swan, Mo. Received through Mr. B. F. Bush, February, 1900. Distributed.

4594. ILEX DECIDUA. **Deciduous holly.**

From Pleasant Grove, Mo. Received through Mr. B. F. Bush, February, 1900. Distributed.

4595. VIBURNUM RUFOTOMENTOSUM.

From Chadwick, Mo. Received through Mr. B. F. Bush, February, 1900. Distributed.

4596. GLEDITSIA.

From Brazoria, Tex. Received through Mr. B. F. Bush, February, 1900. Distributed.

4597. CRATÆGUS MOLLIS.

From Courtney, Mo. Received through Mr. B. F. Bush, February, 1900.

4598. SMILAX HISPIDA.

From Courtney, Mo. Received through Mr. B. F. Bush, February, 1900.

4599. SYMPHORICARPOS VULGARIS.

From Kansas. Presented by Mr. Leon Swingle, through Mr. W. T. Swingle, February, 1900.

4600. LOTUS SERICEUS. **Dakota vetch.**

From South Dakota. Received through Mr. A. J. Pieters, February, 1900. Collected by Mr. L. P. Reinoehl.

4601. ECHINOPS SPHÆROCEPHALUS. **Chapman's honey plant**

From Berkeley, Cal. Presented by Prof. J. Burtt Davy, December, 1899. Distributed.

4602. MAMMILLARIA GRAHAMI.

From Washington, D. C. Received through Mr. W. T. Swingle, February, 1900. Distributed.

4603. MAMMILLARIA GRAHAMI.

From Washington, D. C. Received through Mr. W. T. Swingle, February, 1900. Distributed.

4604. LOPHOPHORA.

From Washington, D. C. Received through Mr. W. T. Swingle, February, 1900. Distributed.

4605. LOPHOPHORA.

From Washington, D. C. Received through Mr. W. T. Swingle, February, 1900. Distributed.

4606. LOPHOPHORA WILLIAMSII.

From Washington, D. C. Received through Mr. W. T. Swingle, March, 1900. Distributed.

4607. BRACHYCHITON ACERIFOLIA. **Flame tree.**

From Santa Ana, Cal. Presented by Dr. John M. Lacy through Mr. Newton B. Pierce.

4608. CELASTRUS SCANDENS.

From Manhattan, Kans. Presented by Mr. J. F. Swingle, through Mr. W. T. Swingle, March 8, 1899.

4609. BRAHEA GUADALUPENSIS ?

From La Paz, Lower California, Mexico. Received through Mr. W. T. Swingle, February, 1900.

4610. PHŒNIX DACTYLIFERA. **Date.**

From Washington, D. C. Received through Mr. W. T. Swingle, March, 1900.

Deglet Noor. Bought at a Washington fruit market. Distributed.

4611. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Deglet Noor.

4612. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Degla Beida.

4613. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Todala techeleff. Distributed.

4614. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Horra. Distributed.

4615. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Possibly *Medjhoul.* A large, unnamed date.

4616. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Deglet Noor.

4617. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Tedalla (?).

4618. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Ghero. Distributed.

4619. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Bent Kabala (?). Distributed.

4620. PHŒNIX DACTYLIFERA. **Date.**

Probably from M'Zab oasis, Sahara. Presented by Yahia ben Kassem, through Mr. W. T. Swingle, March, 1900.

Possibly *Medjhoul.* An unnamed, medium-sized fruit. Distributed.

4621. ANDROPOGON SORGHUM. **Kafir corn.**

From Berryton, Kans. Presented by Mr. M. Mathewson, March 6, 1900.

Mammoth black-hulled white. Distributed.

4622. DIOSPYROS VIRGINIANA. **Persimmon.**

From Lodema, Mo. Presented by Mr. R. A. W. Argenbright, March 10, 1900.

4623. NICOTIANA TABACUM. **Tobacco.**

From Sagua la Grande, Cuba. Presented by Feodoro Miranda, March 12, 1900.

4624. CRATÆGUS MEXICANA. **Haw.**

From Coahuila, Mexico. Presented by Prof. Felix Foëx, of Torreon. Received March 12, 1900.

4625. CRATÆGUS MEXICANA. **Haw.**

From Coahuila, Mexico. Presented by Prof. Felix Foêx, of Torreon. Received March 12, 1900.

Seeds from fruits of largest size and finest flavor.

4626. GOSSYPIUM BARBADENSE. **Cotton.**

From Egypt. Received March 13, 1900.

Gordon Pasha. An improved strain of Egyptian cotton, introduced for the first time. Seed purchased in Italy.

4627. PHASEOLUS VULGARIS. **Bean.**

From San Antonio, N. Mex. Received from Mr. C. B. Allaire, March 13, 1900.

A variety commonly grown by the Mexicans. It forms the staple food of the laboring classes of New Mexico.

4628. Glycine hispida. **Soy bean.**

From Massachusetts. Received March 13, 1900.

Medium green. Distributed.

4629. Medicago sativa. **Alfalfa.**

From Colorado. Received March 16, 1900.

Colorado-grown seed. Distributed.

4630. Ficus elastica. **India rubber.**

From Italy. Received March 13, 1900. Distributed.

4631. Triticum vulgare. **Wheat.**

From Idaho. Received March 14, 1900.

Canadian Hybrid. One of the standard wheats grown in Idaho, Wyoming, and Washington.

4632. Centaurea odorata. **Dusty miller.**

From Italy. Received May 19, 1900. Presented by Dammann & Co., of San Giovanni a Teduccio, near Naples, Italy, through Hon. A. H. Byington, United States consul at Naples.

Centennial Chameleon. "A new hybrid annual which changes color several times during the season. Plant in pots and transplant to sunny spot in rich soil." (*Dammann.*)

4633. Triticum vulgare. **Wheat.**

From Idaho. Received March 14, 1900.

Red Chaff. One of the standard wheats of Idaho, Washington, and Oregon.

4634. Pyrus baccata genuina. **Siberian crab-apple.**

From Russia. Received March 18, 1900. Presented by Dr. A. Fischer von Waldheim, director of the Imperial St. Petersburg Botanic Garden. Distributed.

4635. Nicotiana tabacum. **Tobacco.**

From Sumatra. Received March 21, 1900.

Deli.

4636. Erythrina. **Coral tree.**

From Mexico. Received March 21, 1900. Presented by Mr. Herman Meenen, of Harsenville, Fla.

Zumpantle, or *Coralines.*

4637. Cobæa scandens. **Cobæa.**

From Mexico. Received March 21, 1900. Presented by Mr. Herman Meenen, of Harsenville, Fla.

A vigorous climbing plant with beautiful blue flowers.

4638. Anona cherimolia. **Cherimoya.**

From Mexico. Received March 21, 1900. Presented by Mr. Herman Meenen, of Harsenville, Fla.

"Considered by many one of the finest fruits in existence. Being very tender, it can only be grown successfully in the extreme southern portion of Florida." (*Meenen.*)

4639. Cannabis sativa. **Hemp.**

From Kentucky. Received March 22, 1900. Distributed.

4640–4748. Vitis vinifera. **Grape.**

A collection of European grapes from Alexandre Tacussel, of Vaucluse, France, imported in cooperation with the Division of Pomology. No cuttings are now available for distribution. (See Nos. 2381–2541, Inventory No. 5.) Distributed.

4640. Admirable de Courtiller.
4641. Admirable de Courtiller.
4642. Bicane.
4643. Burgrave de Hongrie.
4644. Chasselas Napoléon.
4645. Cornichon blanc.
4646. Cornichon noir.
4647. Dattier de Beyrouth.
4648. Diamant Traube.
4649. Fintindo.
4650. Foster's seedling.
4651. Frankenthal hâtif.
4652. Général Lamarmora.
4653. Général Lamarmora.
4654. Golden Champion.
4655. Gradiska.
4656. Henab Turki.
4657. Joannenc.
4658. Joannenc.
4659. Zabalkanskoi.
4660. Malvoisie de Sitjes.
4661. Malvoisie de Sitjes.
4662. Mamelon.
4663. Mamelon.
4664. Muscat de Madère rose.
4665. Muscat hâtif du Puy de Dôme.
4666. Muscat St. Laurent.
4667. Olivette de Cadenet.
4668. Olivette de Cadenet.
4669. Pis de Chevre des Alpes.
4670. Rosaki.
4671. Sultanina.
4672. Trentham black.
4673. Trentham black.
4674. Verdelho de Madère.
4675. Verdelho de Madère.
4676. Actoni Macéron.
4677. Aibathy Isjum.
4678. Angélina.
4679. Angulata.
4680. Baude.

4640–4748. Vitis vinifera—Continued.

4681. Bellino.
4682. Bermestia bianca.
4683. Boheraave.
4684. Chasselas St. Bernard.
4685. Citronelle.
4686. Citronelle.
4687. Duc de Magenta.
4688. Frankenthal blanc.
4689. Hambourg blanc.
4690. Imperial.
4691. Karoad.
4692. Merveille de Vaucluse.
4693. Muscat noir précoce.
4694. Muscat de Saumur.
4695. Muscat violet.
4696. Olivette rose.
4697. Raisaine de Pulliat.
4698. West St. Peters.
4699. Chasselas de Jérico.
4700. Gamay de Bourgogne.
4701. Gruner Muscateller.
4702. Long noir d'Espagne.
4703. Olivette noir.
4704. Razaki zolo.
4705. Agostenga.
4706. Agostenga.
4707. Muscat Bowood.
4708. Buckland Sweetwater.
4709. Calabrèse.
4710. Calabrèse.
4711. Chasselas de Florence.
4712. Chasselas de Montauban.
4713. Chasselas de Negrepont.
4714. Chasselas de Negrepont.
4715. Chasselas musqué vrai.
4716. Chasselas musqué vrai.
4717. Chasselas violet.
4718. Chasselas Napoléon.
4719. Chasselas rose royal.
4720. Tokay blanc.
4721. Clairette pointue.
4722. Cornichon noir.
4723. Diamant Traube.

4640-4748. VITIS VINIFERA—Continued.

4724. FOLLE BLANCHE.
4725. JOANNENC CHARNU.
4726. LUGLIENGA NÉRA.
4727. MADELEINE ANGEVINE.
4728. MADELEINE ANGEVINE.
4729. BICOLOR.
4730. MUSCAT DE ALEXANDRIE.
4731. MUSCAT DE ALEXANDRIE.
4732. MUSCAT DE HAMBOURG.
4733. MUSCAT DE HAMBOURG.
4734. MUSCAT ROUGE DE MADÈRE.
4735. ZABALKANSKOI.
4736. PARC DE VERSAILLES.
4737. PARC DE VERSAILLES.
4738. PINOT NOIR DE BOURGOGNE.
4739. PINOT BLANC.
4740. PINOT BLANC DE CHARDONNAY.
4741. PIS DE CHEVRE NOIR.
4742. PRECOCE DE COURTILLER.
4743. ROSAKI.
4744. ROUSSELET.
4745. SERVAN.
4746. SERVAN.
4747. SIRAH DE L'ERMITAGE.
4748. ULLIADE NOIR.

4749. (Blank.)

4750. PISTACIA TEREBINTHUS. **Terebinth.**

Presented by Mr. G. P. Rixford, of the California Academy of Sciences, San Francisco, Cal., January, 1900.

To be used for stocks on which to graft the pistache. Distributed.

4751. TUBER MELANOSPERMA. **Truffle.**

From Paris, France. Received March 30, 1900.

(See No. 2230, Inventory No. 5.) Distributed.

4752. FICUS CARICA. **Smyrna fig.**

From California. Presented by Mr. George C. Roeding, March, 1900.

4753. PERSEA PUMILA.

From Eustis, Fla. Presented by Mr. Frank W. Savage, March, 1899.

4754-4808.

A collection of seeds of native American plants growing near Washington, D. C. Presented by the Seed Laboratory, March, 1900.

4754. CLEMATIS OCHROLEUCA.
4755. EUONYMUS ATROPURPUREUS.

4754–4808—Continued.

4756. Agrimonia parviflora.
4757. Viburnum dentatum.
4758. Saponaria officinalis.
4759. Arctium lappa.
4760. Cratægus crus-galli.
4761. Magnolia acuminata.
4762. Panicum elongatum.
4763. Leonurus cardiaca.
4764. Smilax herbacea.
4765. Vagnera racemosa.
4766. Polymnia uvedalia.
4767. Smilax rotundifolia.
4768. Polygonum sagittatum.
4769. Lobelia inflata.
4770. Alnus rugosa.
4771. Magnolia tripetala.
4772. Saururus cernuus.
4773. Agropyron tenerum.
4774. Euonymus americanus.
4775. Elephantopus.
4776. Polygonum dumetorum.
4777. Silphium trifoliatum.
4778. Andropogon nutans.
4779. Onosmodium caroliniana.
4780. Monarda punctata.
4781. Erechtites hieracifolia.
4782. Nyssa aquatica.
4783. Benzoin benzoin. Distributed.
4784. Baptisia australis.
4785. Xolisma ligustrina.
4786. Prunella vulgaris.
4787. Vaccinium stamineum.
4788. Verbesina occidentale.
4789. Staphylea trifolia.
4790. Apocynum album.
4791. Cassia nictitans.
4792. Lechea racemulosa.
4793. Cyperus ovularis.
4794. Polygonum punctatum.
4795. Rosa humilis.
4796. Pentstemon lævigatus.
4797. Helenium autumnale. Distributed.
4798. Tecoma stans.
4799. Gemminga chinensis.

4754-4808—Continued.

4800. Solidago serotina.

4801. Andropogon provincialis. Distributed.

4802. Poa compressa.

4803. Eupatorium perfoliatum. Distributed.

4804. Phytolacca decandra.

4805. Dipsacus sylvestris.

4806. Verbesina alternifolia.

4807. Gaura biennis.

4808. Vernonia. Distributed.

4809. Andropogon sorghum. **Kafir corn.**

From Manhattan, Kans. Presented by Prof. H. M. Cottrell, through Mr. W. T. Swingle, April, 1900.

Black-hulled White.

4810. Andropogon sorghum. **Kafir corn.**

From Manhattan, Kans. Presented by Prof. H. M. Cottrell, through Mr. W. T. Swingle, April, 1900.

Red. Distributed.

4811. Phœnix dactylifera. **Date.**

From Washington, D. C. Received through Mr. W. T. Swingle, March, 1900. Distributed.

4812. Phœnix dactylifera. **Date.**

From Washington, D. C. Received through Mr. W. T. Swingle, March, 1900. Distributed.

4813. Phœnix dactylifera. **Date.**

From Guaymas, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4814. Fraxinus velutina. **Ash.**

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899. Distributed.

4815. Phoradendron juniperinum.

From Mescalero, N. M. Presented by Miss Minnie Pincumb, through Mr. W. T. Swingle, December, 1899.

Parasite on fir. Distributed.

4816. Karwinskia parviflora.

From Hermosillo, Mexico. Received through Mr. W. T. Swingle, December, 1899.

Shrub 2 to 3 feet high. Leaves like *Psidium guava.*

4817. Cereus pringlei.

From Guaymas, Mexico. Presented by the U. S. National Museum, March, 1900.

4818. Cereus pecten-aboriginum.

From Mazatlan, Mexico. Presented by the U. S. National Museum, March, 1900.

4819. RUBUS.

From Puyallup, Wash. Received through Mr. W. T. Swingle, October, 1899.

A perennial evergreen blackberry. Distributed.

4820. CELASTRUS SCANDENS. **Bittersweet.**

From Manhattan, Kans. Presented by Mr. J. F. Swingle, March, 1900. Distributed.

4821. LOPHOPHORA LEWINII.

From Washington, D. C. From plants growing in S. P. I. greenhouse. Received March, 1900. Distributed.

4822. PANICUM BULBOSUM.

From Washington, D. C. From plants growing in S. P. I. greenhouse. Received March, 1900.

A panicled grass, resembling a small *Sorghum halapense*. Distributed.

4823 QUERCUS MACROCARPA. **Bur oak.**

From Manhattan, Kans. Presented by Prof. A. S. Hitchcock, April 20, 1900.

4824. BOUTELOUA CURTIPENDULA.

From Manhattan, Kans. Presented by Prof. A. S. Hitchcock, April 20, 1900. Distributed.

4825. BULBILIS DACTYLOIDES. **Buffalo grass.**

From Manhattan, Kans. Presented by Prof. A. S. Hitchcock, April 20, 1900.

4826–4840.

From Avalon, Santa Catalina Island, California. Received through Mrs. Blanche Trask, May 1, 1900. A collection of seeds of native plants as follows:

4826. ANTIRRHINUM SPECIOSUM. Distributed.
4827. LUPINUS.
4828. HETEROMELES ARBUTIFOLIA.
4829. LEPTOSYNE GIGANTEA.
4830. CERCOCARPUS TRASKIÆ.
4831. CROSSOSOMA CALIFORNICUM.
4832. ERIOGONUM GIGANTEUM.
4833. ARCTOSTAPHYLOS BICOLOR.
4834. QUERCUS TOMENTELLA.
4835. ERIOPHYLLUM NEVINII.
4836. QUERCUS MACDONALDI.
4837. LAVATERA ASSURGENTIFOLIA.
4838. CEANOTHUS ARBOREUS.
4839. ARCTOSTAPHYLOS DIVERSIFOLIA.
4840. RIBES VIBURNIFOLIA.

4841. CRESCENTIA ALATA.

From California. Presented by Dr. F. Franceschi, through Dr. Edward Palmer, May 5, 1900.

4842. (Blank.)

4843. (Blank.)

4844–4854. TRIFOLIUM PRATENSE. **Red clover.**

From Hamburg, Germany. Received March 17, 1900.

This collection of seed of various red clovers was imported for use in a series of cooperative experiments conducted by the agricultural experiment stations of Minnesota and Wisconsin. It is often claimed that the American strains of red clover are of less value for forage than the European. It is also stated by various agriculturists that the cause of this inferiority is the greater narrowness of the leaves and the coarser and more weedy habit of growth of the stems. However, the amount of forage per acre is said to be greater in the case of the American than of the European forms. The experiments at the above-mentioned stations are being connected in order to determine whether such differences as are claimed really exist between the best American and the European varieties or forms. They are as follows:

4844. HUNGARIAN.

4845. ITALIAN.

4846. FRENCH.

4847. GALICIAN.

4848. RUSSIAN.

4849. TRANSYLVANIAN.

4850. STEIERMARK.

4851. LEITMERITZ.

4852. NORWEGIAN. Distributed.

4853. GERMAN.

4854. ENGLISH.

4855. TRITICUM VULGARE. **Wheat**

From German East Africa. Received March 20, 1900. Presented by Dr. Wittmack, of the Agricultural High School, Berlin, Germany.

Tabora. A rust-proof winter wheat of excellent yield and quality.

4856–4905.

A collection of seeds and plants from Wuchang, China. Received March 20, 1900. Presented by Messrs. G. D. Brill and J. W. Gilmore.

4856. SESAMUM INDICUM. **Sesame.**

Heh-scz-ma; black sesame. (No. 27.) "This is not so extensively grown here as the white sesame, No. 4857." (*Gilmore.*)

4857. SEASAMUM INDICUM. **Sesame.**

Beh-scz-ma; white sesame. (No. 25.)

4858. PHASEOLUS VULGARIS. **Bean.**

Ni-do. (No. 13.)

4859. CUCURBITA.

Lang gua. (No. 4.) "A large gourd or pumpkin." (*Gilmore.*)

4860. BETA VULGARIS. **Chard.**

Tien beh tsai. (No. 24.) "A sweet, white vegetable. This is the popular summer salad here. It grows larger than either No. 4874 or No. 4896. Several crops of this are taken from the same piece of ground during the course of the summer." (*Gilmore.*)

4856-4905—Continued.

4861. IPOMŒA.

Tso yea rsia; bamboo leaf vegetable. (No. 3.) "This grows here abundantly, but I can not identify the plant by the name. I think, however, it is used something like spinach." (*Gilmore.*)

4862. BRASSICA.

Yo tsai; *oil vegetable.* (No. 12.) "A mustard which is sown in the spring and grown for its seed, from which oil is extracted." (*Gilmore.*)

4863. CAPSICUM ANNUUM. **Red pepper.**

Chin la joa. (No. 29.)

4864. CANAVALIA ENSIFORMIS. **Knife bean.**

Tao do. (No. 2.)

4865. CITRULLUS. **Citron.**

Tung gua. (No. 40.) "A large green gourd, white inside. The largest are about 3 feet long and a foot in diameter." (*Gilmore.*)

4866. AVENA FATUA GLABRESCENS. **Wild oat.**

Red oats. (No. 43.)

4867. MOMORDICA. **Gourd.**

Ku gua. (No. 16.) "A kind of squash which is very warty, and red when ripe." (*Gilmore.*)

4868. CUCUMIS SATIVUS. **Cucumber.**

Whang gua; yellow cucumber. (No. 14.) "This is grown very extensively here in the spring, though it does not yield abundantly." (*Gilmore.*)

4869. CHÆTOCHLOA ITALICA. **Millet.**

Tsan schioh. (No. 36.) "This seed is used for feeding birds." (*Gilmore.*)

4870. RAPHANUS SATIVUS. **Radish.**

Turnip. A white variety. (No. 22.)

4871. SAPIUM SEBIFERUM. **Wax berry.**

Beh jo; white wax berry. (No. 44.) "These are the seeds from the white wax tree. The tree grows from 30 to 60 feet high and bears an abundance of berries on new wood." (*Gilmore.*)

4872. HELIANTHUS ANNUUS. **Sunflower.**

Quei wha. (No. 31.) "This is not grown very extensively here except as an ornament. The flowers are 8 or 10 inches in diameter." (*Gilmore.*)

4873. CELOSIA.

Han tsai. (No. 9.)

4874. BRASSICA. **Petsai.**

Heh beh tsai; black white vegetable. (No. 18.) "This is a winter and spring cabbage, and the habits and appearance are quite like those of No. 4896, except that the leaves are not curled. This winter the temperature has been as low as —5° C. and it has not been injured." (*Gilmore.*)

4875. RAPHANUS SATIVUS. **Radish.**

Loh boh. (No. 21.)

4856–4905—Continued.

4876. Avena fatua glabrescens. **Wild oat.**

Mixed oats. (No. 47.)

4877. Malva. **Mallow.**

Tung han tsai. (No. 19.) "A winter variety." (*Gilmore.*)

4878. Oryza sativa. **Rice.**

Tsan gu. (No. 35.) "This is the ordinary rice which is the great staple of China." (*Gilmore.*)

4879. Zea mays. **Corn.**

U gao liang. (No. 39.) A kind of maize.

4880. Oryza sativa. **Rice.**

Loh gu; glutinous rice. (No. 34.)

4880a. Fagopyrum esculentum. **Buckwheat.**

(No. 34.)

4881. Brassica. **Mustard.**

La tsai. (No. 11.) This is a large mustard, and is almost like No. 4887.

4882. Ipomœa bona-nox. **Moonflower.**

Tien chue. (No. 28.)

4883. Sterculia platanifolia.

Wu tung. (No. 45.)

4884. Phaseolus vulgaris. **Bean.**

Tung tsao do. (No. 1.)

4885. Brassica.

Heh beh tsai. (No. 26.)

4886. Lactuca sativa. **Lettuce.**

Wo ju. (No. 17.) "A kind of lettuce. It is sown in beds in the spring and transplanted when the plants are 2 or 3 inches high. It is then well manured and watered until its leaves are a foot or more in height. The plant is grown for the stem, which is sliced and cooked as a vegetable." (*Gilmore.*)

4887. Brassica. **Mustard.**

Gai tsai. (No. 7.) "This is a very large mustard. In exceptional instances the leaves will grow 3 feet long. It is transplanted in the early spring and heavily manured until the leaves reach their full size. The plants are then cut off at the roots and dried; they are then pickled and used throughout the year." (*Gilmore.*)

4888. Hordeum vulgare. **Barley.**

Da meh. (No. 33.) "This is used in the North to some extent for whisky, so I have heard, but here it is used for making sugar for candies and for feeding horses and pigs. It is a winter crop, planted on land which has been overflowed in the summer, or upon cotton, bean, or sesame land." (*Gilmore.*)

4889. Apium graveolens. **Celery.**

Chin tsai. "This seems to be a primitive type. It is small and spindling. It is planted both in the spring and fall in beds and covered with reeds, placed like the roof of a house. When it is about grown fine dirt is sprinkled and sifted among the plants until they are almost covered. The celery bleaches in a short time and is then used as needed." (*Gilmore.*)

4856–4905—Continued.

4890. CRATÆGUS CUNEATA. **Hawthorn.**

San tsao hung. (No. 23.) Fruit about the size of a cherry.

4891. CELOSIA.

Wan tsai. (No. 20.)

4892. AVENA SATIVA. **Oat.**

Black. (No. 42.) "Found growing wild in old gardens and waste places." (*Gilmore.*)

4893. LAGENARIA. **Calabash.**

Hu gua. (No. 15.)

4894. BUTNERIA. **Flowering almond.**

La may wha. (No. 41.)

4895. LUFFA ÆGYPTIACA. **Gourd.**

Tsz gua; silk gourd. (No. 5.) "It sometimes grows 5 feet long and not more than an inch in diameter, except at the bottom. It is planted in the spring and trained on a trellis. The gourds are used for food when they are young and tender." (*Gilmore.*)

4896. BRASSICA. **Petsai.**

Nan kin beh tsai; white vegetable. (No. 6.) "This is a cabbage and is grown extensively in fall and winter." (*Gilmore.*)

4897. SPINACEA OLERACEA. **Spinach.**

Bo tsai. (No. 8.) It is planted in the spring and used as greens.

4898. CHRYSANTHEMUM.

Tung hao. (No. 32.) "According to William's Dictionary this is a kind of celery." (*Gilmore.*)

4899. CITRULLUS VULGARIS. **Watermelon.**

Sez gua tsz. (No. 30.) "They are mainly of two varieties, those of red flesh and those of yellow. Neither grow very large, but the red-fleshed one is preferred to the other. Salted seeds are highly esteemed at dinners and feasts and are eaten throughout the meal." (*Gilmore.*)

4900. PAULOWNIA IMPERIALIS. **Paulownia.**

Yang wu tung. (No. 49.) This is an ornamental tree of rapid growth, having large leaves and flowers very much like those of the catalpa.

4901. ALLIUM. **Garlic.**

Da suan. (No. 46.)

4902. TRITICUM VULGARE. **Wheat.**

Hsioh meh. (No. 37.) "This is extensively grown here for flour. Here, where so much of the land is overflowed in the summer, this is the principal crop on the lowlands, and it is mostly of the bearded kind."

4903. CELTIS. **Hackberry.**

Tang ti hsu. (No. 48.) This tree grows rapidly and to a large size. It is not very common.

4904. CANAVALIA ENSIFORMIS. **Knife bean.**

(No. 2.)

4905. ANDROPOGON SORGHUM. **Sorghum.**

Loh goa liang. (No. 38.) "This is a nonsaccharine sorghum. There are two or three kinds, but the main use of all is for making a kind of whisky." (*Gilmore.*)

4906. NICOTIANA TABACUM. **Tobacco.**

From Turkey. Received April 7, 1900.

Turkish Samsum.

4907. NICOTIANA TABACUM. **Tobacco.**

From Turkey. Received April 7, 1900.

Turkish Bafra.

4908. FRAGARIA VESCA. **Strawberry.**

From France. Received April 10, 1900.

St. Antoine de Padoua, everbearing. "This variety, which was sent out in 1898 by the Abbé Thivolet, was obtained by crossing the St. Joseph with the large-fruited English Royal Sovereign. The fruits of this sort are larger than those of the St. Joseph, are firm, good keepers, and have an excellent flavor. The fruit clusters are erect and do not require support as do those of the St. Joseph. This is the newest and most remarkable of the large-fruited, everbearing strawberries." (*Swingle.*) Distributed.

4909. PRUNUS. **Cherry.**

From Waynesville, N. C. Presented by Dr. G. D. Green. Received April 10, 1900.

"This wild cherry goes by two names—the Peruvian Tree and the Balsam Cherry." (*Green.*) Distributed.

4910. PSIDIUM CATTLEYANUM. **Dwarf guava.**

From Waterloo, Kans. Received March 24, 1900. Presented by Mr. J. W. Riggs.

A seedling of dwarf guava which lives and bears fruit in Kansas. Distributed.

4911. PUNICA GRANATUM. **Pomegranate.**

From Waterloo, Kans. Received March 24, 1900. Presented by Mr. J. W. Riggs.

A very hardy seedling pomegranate which lives and bears fruit in Kansas. Distributed.

4912–4914. GLYCINE HISPIDA. **Soy bean.**

A collection of soy beans from Japan. Received March 23, 1900. They are as follows:

4912. COMMON. Distributed.

4913. BEST WHITE. Distributed.

4914. BEST GREEN. Distributed.

4915–4946.

From Perth, West Australia. Received March 24, 1900. Presented by Mr. E. F. Brady.

A collection of seeds of native West Australian plants.

4915. KINGIA AUSTRALIS.

4916. ACTINOTUS LEUCOCEPHALUS. **Flannel flower.**

4917. LESCHENAULTIA.

A small perennial, 18 inches high, with blue flowers.

4918. **Christmas bush.**

4915-4946—Continued.

4919. GASTROLOBIUM CALYCINUM.

A poison plant.

4920. WAITZIA AUREA.

4921. MYRIOCEPHALUS STUARTII.

4922. **White clematis.**

A handsome climber. Distributed.

4923.

An annual with blue, lobelia-like flowers.

4924. AUSTRALINA MUELLERI. **Kangaroo paw.**

4925. HELICHRYSUM BRACTEATUM. **Everlasting.**

4926. **Flannel flower.**

An annual.

4927. **Coral creeper.**

The seeds must be scalded and soaked before planting.

4928.

A fine summer-flowering plant with pink sprays.

4929. HIBISCUS.

Flowers lilac.

4930.

A small, yellow-flowered legume.

4931.

A dwarf perennial shrub.

4932. **Flannel flower.**

4933.

A bamboo-like plant.

4934.

A native annual lobelia with deep-blue flowers.

4935. HARDENBERGIA.

A climber with fine blue flowers. Makes a fine show in our woods.

4936. BANKSIA.

A short, prickly shrub.

4937. AUSTRALINA.

Tall, green-flowering. Grown on swampy land.

4938. CALLISTEMON. **Scarlet bottle-bush.**

Flowers scarlet. Grows in dry situations.

4939. ACACIA. **Wattle.**

Flowers bright golden. Grows 2 feet high.

4915–4946—Continued.

4940.

Smoke plant.

4941. **Marguerite.**

A perennial with large, single white flowers. Distributed.

4942. HOVEA.

Blue mixed. Distributed.

4943. **Scarlet grevillea.**

A shrub, in dry situations.

4944. BANKSIA GRANDIS. **Bull banksia.**

A handsome tree.

4945.

An annual with white flowers.

4946.

A dwarf plant like *Banksia*, with long, serrated leaves.

4947–4962.

A collection of Mexican species of *Physalis*. Received March 27, 1900. Presented by Dr. Edward Palmer.

4947. PHYSALIS.

From Zacatecas, Mexico. "Fruit the size of a cherry; in color pea green to a yellow tint; quite sticky; used with red peppers in sauce to neutralize the bad effect of excessive use of red pepper." (*Palmer.*)

4948. PHYSALIS.

From San Luis Potosi, Mexico. "A fine species, with a rather flat fruit, plum-colored at base, solid and purplish when ripe." (*Palmer.*)

4949. PHYSALIS.

From Durango, Mexico. "The fruit has a fine aroma; is edible raw; very prolific, of good size, and worthy of cultivation." (*Palmer.*)

4950. PHYSALIS.

From Zacatecas, Mexico. "A species with husk entirely covering the fruit and extending above. Fruit is round and plum-colored." (*Palmer.*)

4951. PHYSALIS ALKENGI.

From Mexico. "Fruit edible raw, of fine flavor." (*Palmer.*)

4952. PHYSALIS.

From San Luis Potosi, Mexico.

4953. PHYSALIS.

From San Luis Potosi, Mexico.

4954. PHYSALIS FENDLERI.

From Acapulco, Mexico. "Used in soups, gravies, and stuffings for fowls. This fruit is found all the year round in the markets of Acapulco." (*Palmer.*)

4947–4962—Continued.

4955. Physalis.

From Mapimi, Durango, Mexico. "Fruit yellow, with an agreeable odor and good to eat. Yields abundantly. A low plant. Worthy of cultivation." (*Palmer.*)

4956. Physalis.

From San Luis Potosi, Mexico. "Large fruit having a husk which opens in two parts so that the top of the fruit is bare. (*Palmer.*)

4957. Physalis.

From San Luis Potosi, Mexico.

4958. Physalis.

From San Luis Potosi, Mexico. "A large-fruited species which is covered entirely by a husk that is purple at the base." (*Palmer.*)

4959. Physalis.

From San Luis Potosi, Mexico. "This form has a very close-fitting, smooth husk with rather prominent veins at the base." (*Palmer.*)

4960. Physalis.

From Durango, Mexico. "This species has a very strong odor and is as sticky as tobacco." (*Palmer.*)

4961. Physalis.

From San Luis Potosi, Mexico. Distributed.

4962. Physalis.

From San Pedro Soapuilla, Aguascalientes, Mexico. "It is one of the finest varieties." (*Palmer.*)

4963. Nicotiana. **Tobacco.**

From Durango, Mexico. Received March 27, 1900. Presented by Dr. Edward Palmer.

"Strong grower, large leaves, very gummy, strong odor; once used by native population." (*Palmer.*) Distributed.

4964. Pennisetum spicatum. **Pearl millet.**

From Kangundo, British East Africa. Presented by Mr. Charles F. Johnston.

Nirali. Distributed.

4965-5002.

From Yokohama, Japan. Received March 27, 1900. A collection of vegetable seeds presented by Suzuki & Iida, New York City.

4965. Citrullus vulgaris. **Watermelon.**

4966. Phaseolus vulgaris. **Bean.**

4967. Cryptotænia canadensis.

Mitsuba.

4968. Brassica napus. **Turnip.**

Tennoji.

4969. Salsola soda.

4965–5002—Continued.

4970. Canavalia ensiformis. **Knife bean.**
Natamame.

4971. Perilla arguta.

4972. Tetragona expansa. **New Zealand spinach.**

4973. Dolichos umbellatus.
Jinroku-sasage.

4974. Dolichos umbellatus.
Sanjak-sasage.

4975. Beta vulgaris. **Beet.**
Fudanso.

4976. Cucurbita longa.
Naga-yugao.

4977. Allium porrum. **Leek.**
Tokio.

4978. Allium porrum. **Leek.**
Iwatsuki.

4979. Allium porrum. **Leek.**
Shimo-vita.

4980. Glycine hispida. **Soy bean.**
Early soja.

4981. Lappa major.
Yamato.

4982. Lappa major.
Red Stalk.

4983. Lappa major.
Sunagawa.

4984. Phaseolus vulgaris. **Bean.**
Buff.

4985. Phaseolus vulgaris. **Bean.**
Prolific climber.

4986. Chrysanthemum coronarium. **Edible chrysanthemum.**

4987. Luffa ægyptiaca. **Vegetable sponge.**

4988. Daucus carota. **Carrot.**
Long red.

4989. Cucumis sativus. **Cucumber.**
Late.

4990. Cucumis sativus. **Cucumber.**
Medium green.

4965–5002—Continued.

4991. Cucumis sativus. Cucumber.

Joint fruiting.

4992. Cucumis sativus. Cucumber.

Common.

4993. Cucumis melo. Muskmelon.

Makwa-wir.

4994. Solanum melongena. Egg plant.

Sadowara.

4995. Solanum melongena. Egg plant.

Early prolific.

4996. Raphanus sativus. Radish.

Everlasting.

4997. Raphanus sativus. Radish.

Summer.

4998. Raphanus sativus. Radish.

Long Otapuka.

4999. Benincasa cerifera. Wax gourd.

5000. Lagenaria vulgaris. Large gourd.

Ohiotau.

5001. Cucurbita maxima. Pumpkin.

5002. Cucurbita maxima. Pumpkin.

Early Crèpe.

5003–5020.

From Yokohama, Japan. Received March 27, 1900. A collection of seeds of the native forest trees of Japan, presented by Suzuki & Iida, of New York City.

5003. Abies brachyphylla. Fir.

5004. Abies firma. Fir.

5005. Abies veitchii. Fir.

5006. Carpinus yedoensis. Hornbeam.

5007. Celtis bungeana. Hackberry.

5008. Cornus kousa. Cornel.

5009. Cryptomeria japonica. Distributed.

5010. Edgeworthia gardneri.

5011. Elæagnus umbellatus.

5012. Illicium anisatum.

5013. Juglans sieboldiana. Walnut.

5014. Juniperus rigida. Juniper.

5015. Quercus acuta. Oak.

5016. Rhus succedanea. Tallow tree.

5017. Thea viridis. Distributed. Tea.

5003–5020—Continued.

5018. Torreya nucifera.

5019. Xanthoxylon piperitum.

5020. Zelkova acuminata.

5021. Cannabis sativa. **Hemp.**

From Shanghai, China. Received March 28, 1900. Presented by Dr. Kung, through Mr. Young S. Allen. Distributed.

5022. Thea viridis. **Tea.**

From Heneratgoda, Ceylon. Received March 28, 1900.

Best Assam Hybrid. Distributed.

5023. Landolphia kirki.

From Heneratgoda, Ceylon. Received March 28, 1900.

This is one of the African lianes from which commercial rubber is extracted. Distributed.

5024. Urceola esculenta.

From Heneratgoda, Ceylon. Received March 28, 1900.

An East Indian rubber plant. Distributed.

5025. Opuntia pubescens.

From Heneratgoda, Ceylon. Received March 28, 1900. Presented by J. P. William & Bros.

A prickly-pear cactus which is valuable as a forage plant. Distributed.

5026. Nopalia cochinellifera.

From Heneratgoda, Ceylon. Received March 28, 1900. Presented by J. P. William & Bros. Distributed.

5027. Payena leerii.

From Heneratgoda, Ceylon. Received March 28, 1900.

An East Indian rubber plant. Distributed.

5028. Manihot glaziovii. **Ceara rubber.**

From Heneratgoda, Ceylon. Received March 28, 1900. Distributed.

5029. Mimusops elengi.

From Heneratgoda, Ceylon. Received March 28, 1900.

An East Indian tree from which a commercial guttapercha is extracted. Distributed.

5030. Cucumis sativus. **Cucumber.**

From Heneratgoda, Ceylon. Received March 28, 1900. Presented by J. P. William & Bros.

An especially fine cucumber for cultivation in the tropics.

5031. Secale cereale. **Rye.**

From Schlansted, Germany. Received March 30, 1900.

Schlansted Winter. An improved strain, originated in Germany. The grain is one of the best for bread-making purposes.

5032. AVENA SATIVA. **Oat.**

From France. Received March 30, 1900.

Avoine rousse couronnée. "Grain red, short; chaff very thin; straw is stiff and does not lodge readily; very productive, but late." (*Vilmorin.*)

5033. NICOTIANA TABACUM. **Tobacco.**

From Sumatra. Received March 30, 1900.

Sumatra Rano.

5034. ASTRAGALUS FALCATUS.

From France. Received March 30, 1900.

A leguminous forage plant.

5035. TRITICUM MONOCOCCUM. **Einkorn.**

From France. Received March 30, 1900.

Engrain. Distributed.

5036. TRITICUM MONOCOCCUM. **Einkorn.**

From France. Received March 30, 1900.

Commun. (See No. 5035.) Distributed.

5037. BETA VULGARIS. **Mangold.**

From Paris, France. Presented by Vilmorin-Andrieux et Cie. Received March 30, 1900.

Giant Half-sugar Rose.

5038. BETA VULGARIS. **Mangold.**

From Paris, France. Presented by Vilmorin-Andrieux et Cie. Received March 30, 1900.

Giant Half-sugar White. (See No. 5037.)

5039. GLYCINE HISPIDA. **Soy bean.**

From Paris, France. Received March 30, 1900. Presented by Vilmorin-Andrieux et Cie.

Extra early black-seeded. A very early maturing strain.

5040. PACHYRHIZOS TUBEROSUS. **Yam-bean.**

From Italy. Received April 2, 1900.

Of possible value as a forage plant.

5041. NICOTIANA TABACUM. **Tobacco.**

From Italy. Received April 2, 1900.

Turkish Bafra. (See No. 4378.)

5042. VIGNA CATJANG. **Cowpea.**

From Georgia. Received April 4, 1900.

New Era. The earliest maturing variety of cowpea known. Distributed.

5043. FRAGARIA VESCA. **Strawberry.**

From Irapuato, Guanajuato, Mexico. Received April 6, 1900.

An everbearing strawberry. Distributed.

5044-5047. TRIFOLIUM PRATENSE. **Red clover.**

From Vienna, Austria-Hungary. Received April 7, 1900.

A collection of European red clovers:

5044. HUNGARIAN.

5045. RUSSIAN.

5046. STEIERMARK.

5047. TRANSYLVANIAN.

5048. TRITICUM VULGARE. **Wheat.**

From Minnesota. Received April 10, 1900. Presented by Prof. W. M. Hays, of the Agricultural Experiment Station, St. Anthony Park, Minn.

Minn. No. 169. Distributed.

5049. TRITICUM VULGARE. **Wheat.**

From Minnesota. Received April 10, 1900. Presented by Prof. W. H. Hays, of the Agricultural Experiment Station, St. Anthony Park, Minn.

Minn. No. 187. Distributed.

5050. TRITICUM VULGARE. **Wheat.**

From Minnesota. Received April 10, 1900. Presented by Prof. W. M. Hays, of the Agricultural Experiment Station, St. Anthony Park, Minn.

Minn. No. 149. Distributed.

5051. TRITICUM VULGARE. **Wheat.**

From Shanghai, China. Received through Consul-General Goodnow, April 11, 1900.

Pootung. Said to be grown on the lowlands between the Hwang-ho and Yangtse rivers. The Chinese report that this wheat is never attacked by rust.

5052. POA VIOLACEA.

From Steiermark, Bohemia. Received April 14, 1900. Presented by the director of the Samen Control Station, Vienna.

"From the Alps, near Aussee, at an altitude of 4,200 feet." Distributed.

5053. **Confederate grass.**

From Victoria, Tex. Received April 12, 1900. Presented by Mr. William Benton. Distributed.

5054. TRITICUM VULGARE. **Wheat.**

From Douglas, Wyo. Received April 14, 1900. Presented by Mr. B. C. Wheelock.

Seven-head wheat. "This wheat yielded 43 bushels per acre and weighed 63 pounds to the bushel."

5055. ZEA MAYS. **Corn.**

From Douglas, Wyo. Received April 14, 1900. Presented by Mr. B. C. Wheelock.

Longfellow. "This flint corn ripens in from 80 to 90 days from time of planting. It yields a heavy crop." (*Wheelock.*)

5056. EUGENIA UNIFLORA. **Surinam cherry.**

From Lemon City, Fla. Received April 13, 1900. Presented by Mr. E. J. Brown. Distributed.

5057. PANICUM MILIACEUM. **Broom-corn millet.**

From Walla Walla, Wash. Received April 16, 1900.

Seed grown in Washington. The original was imported by Prof. N. E. Hansen for this Department from Russia.

5058. SECALE CEREALE. **Rye.**

From Germany. Received through a French seedsman, April 26, 1900.

Petkus. This is an improved strain originated by a plant breeder at Petkus, a small town about 40 miles south of Berlin. It is one of the best varieties for bread making.

5059. AVENA SATIVA. **Oat.**

From Italy. Received through a French seedsman, April 26, 1900.

Gentile primo vera d' Umbria. A very early maturing variety with panicled heads and tall straw.

5060. BOUTELOUA OLIGOSTACHYA. **Blue grama.**

From Silver City, N. Mex. Received March 1, 1900. Distributed.

5061. LYCURUS PHLEOIDES. **Timothy grama.**

From Silver City, N. Mex. Received March 1, 1900. Distributed.

5062. MUSA. **Banana.**

From Manila, P. I. Received through Messrs. Lathrop and Fairchild (No. 389), April 14, 1900.

"A variety of banana with fruit filled with seed. The flavor is quite different from any other variety known to me and very agreeable. Imported for breeding experiments." (*Fairchild.*) Distributed.

5063. MANGIFERA INDICA. **Mango.**

From Manila, P. I. Received through Messrs. Lathrop and Fairchild (No. 390), April 14, 1900.

"Two seeds of a most delicious variety (name unknown) of mango, grown near Manila. Large, orange yellow, kidney-shaped. Pronounced by Mr. Lathrop as good as any Indian mango he ever ate. Very little fiber." (*Fairchild.*) Distributed.

5064. CAPSICUM ANNUUM. **Red pepper.**

From Manila, P. I. Received through Messrs. Lathrop and Fairchild (No. 388), April 14, 1900.

"Seeds of a large, bright-red, sweet pepper from Manila market." (*Fairchild.*) Distributed.

5065. MELALEUCA LEUCODENDRON. **Cajuput.**

From France. Received April 30, 1900.

An evergreen tree of large size, native from the Malayan Archipelago to Australia. Cajuput oil, extensively used in medicine, is extracted from the leaves. Distributed.

5066. MUCUNA UTILIS. **Velvet bean.**

From Florida. Received May 1, 1900. Presented to Hon. J. H. Brigham, Assistant Secretary of Agriculture, by Mr. Kline O. Varn, of Fort Meade, Fla. (See No. 4333, Inventory No. 8.)

5067. AGARICUS CAMPESTRIS. **Mushroom.**

From France. Received May 5, 1900. Presented by Vilmorin-Andrieux et Cie., Paris, France.

Vilmorin's New Mushroom Spawn. Grown from spores of the best mushrooms by Dr. Repin's process.

5068. LESPEDEZA STRIATA. **Japan clover.**

From Sardis, Miss. Received May 5, 1900.

An annual plant of especial value for covering barren soils in the Southern States.

5069. CANAVALIA ENSIFORMIS. **Knife bean.**

From Wahiawa, Oahu, H. I. Received May 8, 1900. Presented by Hon. Byron O. Clark.

"A large white bean brought here from California by a gardener. It is a strong grower and very productive." (*Clark.*)

5070. DOLICHOS. **Tongan bean.**

From Wahiawa, Oahu, H. I. Received May 8, 1900. Presented by Hon. Byron O. Clark.

"Imported from Australia. This bean will cover a trellis or outhouse. One plant will yield bushels of delicious beans, which may be either cut up like a French bean or shelled when nearly ripe. As the seed germinates slowly, it has been found a good plan to soak in boiling water before planting, so as to soften the hard outer skin." (*Clark.*)

5071. PHASEOLUS MUNGO. **Green gram.**

From Wahiawa, Oahu, H. I. Received May 8, 1900. Presented by Hon. Byron O. Clark.

A native of China

5072. PHASEOLUS MUNGO. **Green gram.**

From Wahiawa, Oahu, H. I. Received May 8, 1900. Presented by Hon. Byron O. Clark.

A native of China.

5073. CUCURBITA PEPO. **Vegetable marrow.**

From Wahiawa, Oahu, H. I. Received May 8, 1900. Presented by Hon. Byron O. Clark.

A native of Australia. "Very choice as a green squash; used as our butter squashes are." (*Clark.*)

5074. POLYGALA BUTYRACEA. **Polygala.**

From Paris, France. Received May 8, 1900. Presented by A. Godefroy-Lebeuf.

This plant produces a vegetable butter. It will grow in summer in the hot portions of California and Florida, and as the plants can be grown as annuals it will probably prove successful.

5075. TRITICUM VULGARE. **Wheat.**

From New South Wales, Australia. Received May 8, 1900.

Allora. This variety is obtained in Australia, though it is said to have come originally from California. It is medium or small in height, with red, bald, or slightly bearded heads. The grain is soft and white, and produces flour with a low gluten content. Its particularly valuable quality for this country is its earliness in ripening, although it is usually rather rust-resistant (at least in Australia) and fairly drought-resistant. It is adapted to the Southern States, but might also be tried in Oregon, northern California, and southeastern Washington. It is a winter variety in mild climates.

5076. TRITICUM VULGARE. **Wheat.**

From New South Wales, Australia. Received May 8, 1900.

Steinwedel. This is a winter variety for mild climates. It has bald heads, soft, white grains, and produces a weak flour of fair gluten content. It is particularly resistant to drought, and ripens early; is adapted to our Southern States, but may well be tried in our Pacific coast States. It is not considered a good milling wheat in Australia.

5077. TRITICUM VULGARE. **Wheat.**

From New South Wales, Australia. Received May 8, 1900.

Canning Downs. This variety is a wheat of short growth, with bearded heads. It ripens very early, and possesses a fair quality of grain, but is not hardy. It is adapted for trial in the Southern States west to Texas, and, because of its early maturity, should be tested in Oregon and southeastern Washington.

5078. TRITICUM VULGARE. **Wheat.**

From New South Wales, Australia. Received May, 8, 1900.

Early Baart. This is an early-ripening variety, adapted to the Pacific States. It is a winter variety in mild climates.

5079. TRITICUM VULGARE. **Wheat.**

From New South Wales, Australia. Received May 8, 1900.

King's Early. This is a winter variety for mild climates. It produces a rather soft grain and is very early in ripening. It is adapted to the Southern States, and may well be tried in the Pacific coast States.

5080. BROMUS UNIOLOIDES. **Rescue grass.**

From New South Wales, Australia. Received May 8, 1900.

This grass is a native of South America, and possibly also of the southwestern United States. Distributed.

5081. PASPALUM DILATATUM. **Large water grass.**

From New South Wales, Australia. Received May 8, 1900.

A rather coarse-leaved perennial, growing in clumps 2 to 5 feet high, bearing near the summit of the stems 2 to 10 more or less spreading racemes or spikes of crowded, hairy spikelets. Although a native of Brazil, it has now become quite largely introduced throughout the United States.

5082. ATRIPLEX NUMMULARIA. **Round-leaved saltbush.**

From New South Wales, Australia. Received May 8, 1900.

This plant attains a height of from 6 to 10 feet and is highly valued as forage for cattle and sheep. Although it is extensively planted and highly valued in central Australia and South Africa, the experiments with it in this country have not been satisfactory.

5083. ATRIPLEX HALIMOIDES. **Mealy saltbush.**

From New South Wales, Australia. Received May 8, 1900.

A low-growing, shrubby perennial about 1 foot high, with variable, ovate-lanceolate leaves, which are covered with whitish, dust-like scales. It is a native of the Central regions of Australia, where it makes a very rapid growth and begins to bear seeds in three months after sowing. In this country it has not been sufficiently experimented with to state its possibilities.

5084. POA PRATENSIS. **Kentucky blue grass.**

From New York. Received May 5, 1900. Distributed.

5085–5105. CAPSICUM ANNUUM. **Red pepper.**

From British Guiana. Received May 14, 1900. Presented by the Director of the Botanic Gardens. A collection of different varieties, of which but two are named or described:

5085. (1.) Distributed.
5086. (2.) Distributed.
5087. (3.) Distributed.
5088. (4.) Distributed.
5089. (5.) Distributed.
5090. (6.) Distributed.
5091. (7.) Distributed.
5092. (8.) Distributed.
5093. (9.) Distributed.
5094. (10.) Distributed.
5095. (11.) Distributed.
5096. (12.) Distributed.
5097. (13.) Distributed.
5098. (14.) Distributed.
5099. (15.) Distributed.
5100. (16.) Distributed.
5101. (17.) Distributed.
5102. (18.) Distributed.
5103. (19.) Distributed.
5104. (20.) *Killmissy.* Distributed.
5105. (21.) Black when young, yellow when ripe.

5106. CAPSICUM FRUTESCENS BACCATUM. **Bird pepper.**

See Nos. 5085–5105. Distributed.

5107. HUMULUS LUPULUS. **Hop.**

From Bohemia. Received through Messrs. Lathrop and Fairchild (No. 252), May 15, 1900.

Red Semsch. A variety, originated in Auscha, which has been improved by being grown two years on the red soils of Saaz, the most noted hop region of Bohemia. (See Circular No. 19, Division of Botany.) Distributed.

5108. HUMULUS LUPULUS. **Hop.**

From Bohemia. Received through Messrs. Lathrop and Fairchild (No. 255), May 15, 1900.

The true Saaz hop, less fruitful than Auscha, but with the finest aroma and bitter taste. (See Circular No. 19, Division of Botany.) Distributed.

5109. FICUS CARICA. **Caprifig.**

From Algiers, Algeria. Received through Mr. Walter T. Swingle (No. 1), May 16, 1900. Presented by Dr. Trabut.

From Jardin d'Essai. Distributed.

5110. OLEA EUROPÆA. **Olive.**

From Algiers, Algeria. Received through Mr. Walter T. Swingle (No. 4), May 17, 1900. Presented by Dr. Trabut.

Olive longue de Constantine. "A very large pickling olive of very superior quality, from the Jardin du Hamma, at Constantine." (*Swingle.*) Distributed.

5111. OLEA EUROPÆA. **Olive.**

From Algiers, Algeria. Received through Mr. Walter T. Swingle (No. 5), May 17, 1900.

Round Constantine. Distributed.

5112. CARICA PAPAYA. **Papaw.**

From Honduras. Presented by Dr. R. Fritzgartner, Director of the Mint, Tegucigalpa. Received May 17, 1900.

Large, yellow fruit. Distributed.

5113. FICUS CARICA. **Caprifig.**

From Algiers, Algeria. Received through Mr. W. T. Swingle, May 17, 1900. Distributed.

5114. NICOTIANA TABACUM. **Tobacco.**

From Japan. Received May 17, 1900. Presented to Hon. James Wilson, Secretary of Agriculture, by C. Maki, Director of the Ibraki Prefecture of the Ota Tobacco Monopoly.

Kokubu. "The best tobacco produced in this district. The aromatic leaves are excellent and grade first in Japan." (*Maki.*)

5115–5122.

From Sinaloa, Mexico. A collection of seed presented by Mr. G. Lawton Taylor, of Santa Cruz de Alaya, through the Office of Experiment Stations, May 21, 1900.

5115. CARICA PAPAYA. **Papaw.**

Papai. A tree about 20 feet high; fruit excellent. Distributed.

5116. CARICA PAPAYA. **Papaw.**

Papai. From Oahu, H. I. "Extremely productive and excellent eaten green, cooked as vegetables, or ripe as fruit." (*Taylor.*) Distributed.

5117. BRASSICA JUNCEA. **Chinese mustard.**

Koytoi. "From Asia. Eaten cooked as greens and also made into a sauerkraut." (*Taylor.*) Distributed.

5118. VIGNA CATJANG. **Cowpea.**

Aukok. "A long, black climbing bean from Asia. Eaten as snap beans. Very tender even when old." (*Taylor.*) Distributed.

5119. CUCURBITA PEPO. **Squash.**

Umqua. "A Chinese squash, weighing about 30 to 40 pounds. The squash looks much like a watermelon, but is hollow and will keep a year if not frozen, pieces being cut off and cooked as vegetables." (*Taylor.*) Distributed.

5120. CITRULLUS VULGARIS. **Citron.**

Tequa. "From Asia. Is like the *Umqua* in appearance and weight, but keeps only four months." (*Taylor.*) Distributed.

5121. MOMORDICA CHARANTIA. **Gourd.**

Laqua. "A climber. Fruit looks like a large gherkin. Is cooked with roast meats. Acid fruit weighs about three-fourths of a pound." (*Taylor.*) Distributed.

5122. LUFFA ACUTANGULA. **Gourd.**

Suqua. "From China. A delightful cornucopia-shaped, 10-ribbed vegetable, climber, from 1 to 2½ feet long. Is good raw or cooked. Looks like black watermelon seed." (*Taylor.*) Distributed.

5123. Ficus carica. **Caprifig.**

From Algeria. Received through Mr. W. T. Swingle (No. 3), May 21, 1900. Distributed.

5124. Citrus limonum. **Lemon.**

From Banda, Dutch East Indies. Received through Messrs. Lathrop and Fairchild (No. 350), May 22, 1900.

Sauerbier. A very large, thin-skinned, exceedingly juicy lemon of good flavor. Distributed.

5125. Stipa leucotricha. **Bearded mesquite.**

From Victoria, Tex. Presented by Hon. J. D. Mitchell, May 21, 1900.

This is the best hay grass of the "sedge-grass prairies" of southern Texas. It is a bunchy grass with long and abundant leaves, and grows 3 to 4 feet high.

5126. Rumex hymenosepalus. **Canaigre.**

From San Antonio, N. Mex. Received March 1, 1900. Presented by Mr. C. B. Allaire.

A few seeds from a plant selected for its high tannin content. Distributed.

5127. Cucumis melo. **Muskmelon.**

From Turkey. Received May 24, 1900, through Mr. H. S. D. Ashby, Smithfield, Tex.

"A few seeds sent by Judge A. Terrell from Constantinople. Said to be a very fine melon of delicate flavor." (*Ashby.*)

5128. Caragana frutescens. **Siberian pea tree.**

From Russia. Received through Prof. N. E. Hansen, March, 1898.

5129. Rubus xanthocarpus. **Raspberry.**

From North China. Received through Prof. N. E. Hansen, March, 1898.

Orange-fruited raspberry. From mountains of North China. Fruit large; peculiar, pleasant flavor; semirecumbent habit. Hardy at St. Petersburg. Cultivated in ordinary way. Likely to become a bad weed. Should be watched.

5130-5138.

From Russia. Received through Prof. N. E. Hansen, March, 1898. A collection of seeds as follows:

5130. Rosa rugosa (No. 600.)
5131. Neillia amurensis. (No. 602.) Distributed.
5132. Lonicera chrysantha. (No. 603.)
5133. Clematis alpina. (No. 606.)
5134. Rubus arcticus. (No. 607.) Distributed.
5135. Lonicera alberti. (No. 608.)
5136. Lonicera cærulea dependens. (No. 609.)
5137. Rosa rugosa alba. (No. 610.)
5138. Caragana frutescens grandiflora. (No. 611.)

5139. Avena sativa. **Oat.**

From Kiovikko, Finland. Received through Messrs. Lathrop and Fairchild (No. 433), September 28, 1900.

North Finnish Black. "The climate of Kiovikko is extremely cold. During the winter of 1899-1900 the temperature remained for nearly three weeks at from —4° F.

to —40° F., reaching an extreme minimum of —49° F. Frosts often occur every month during the summer. Seed is sown here in April and May. The harvest occurs at the end of August. This seed was grown at the Finnish Agricultural School of Kiovikko. It matures earlier than any other sort." (*Fairchild.*)

5140. AVENA SATIVA. **Oat.**

From Kiovikko, Finland. Received through Messrs. Lathrop and Fairchild, September 28, 1900.

A white oat which was mixed with No. 5139.

5141. PINUS SILVESTRIS. **Scottish pine.**

From Jokkis, Finland. Received through Messrs. Lathrop and Fairchild (No. 434), September 28, 1900.

5142. PROSOPIS HORRIDA. **Algaroba.**

From Rosario, Argentina. Received September 28, 1900. Presented by Hon. James M. Ayers, United States consul.

"The pods of this tree, which resembles the Mesquite bean of Texas, are extensively used for feeding cattle and for food by the common people. It grows luxuriantly in very dry regions." (*Fairchild.*)

5143. DIOSPYROS TEXENSIS. **Texas ebony.**

From Victoria, Tex. Presented by Mr. E. H. Smith. Received October 1, 1900.

5144. MENTHA PIPERITA. **Peppermint.**

From Hungary. Received October 2, 1900.

5145. TRITICUM VULGARE. **Wheat.**

From Columbia, Mo. Received September 29, 1900.

Fultz. Wheat grown by the Missouri Agricultural Experiment Station.

5146. VICIA CRACCA. **Vetch.**

From Luleå, Sweden. Received through Messrs. Lathrop and Fairchild (No. 437a), October 4, 1900.

5147. VICIA FABA. **Horse bean.**

From Freemansburg, Pa. Presented by Mr. J. H. Denyer. Received October 5, 1900.

(See No. 3997, Inventory No. 8.)

5148. VICIA FABA. **Horse bean.**

From Freemansburg, Pa. Presented by Mr. J. H. Denyer. Received October 5, 1900.

(See No. 3997, Inventory No. 8.)

5149. HICORIA PECAN. **Pecan.**

From Victoria, Tex. Presented by Mr. E. H. Smith. Received October 15, 1900.

5150. TRITICUM VULGARE. **Wheat.**

From Japan. Received May 26, 1900. Presented by Prof. Setsuschuro Tanaka, Agricultural College, Komaba, Tokyo.

Onigara. "Produced in Owada in the Prefecture Scitama, several miles from Tokyo, a region noted for its wheat production."

5151. HIBISCUS SABDARIFFA. **Roselle.**

From Topolobampo, Mexico. Received May 31, 1900. Presented by Mr. A. J. Wilber.

Roselle is used for various culinary purposes; the leaves as greens; the fleshy calyxes for sauces, salads, etc. The dried calyxes are the roselles of commerce.

5152. HALOXYLON AMMODENDRON.

From Russia. Received May 31, 1900. Presented by the Secretary for Agriculture and Mines, Department of Agriculture, St. Petersburg.

Black.

5153. HALOXYLON AMMODENDRON.

From Russia. Received May 31, 1900. Presented by the Secretary for Agriculture and Mines, Department of Agriculture, St. Petersburg.

White.

5154. CAPSICUM ANNUUM. **Red pepper.**

From Surabaya, Java. Received through Messrs. Lathrop and Fairchild (No. 391), June 1, 1900.

"Long red pepper, very silky skinned, three-eighths of an inch in diameter, from the market of Surabaya." (*Fairchild.*)

5155. SOLANUM.

From Canton, China. Received through Messrs. Lathrop and Fairchild (No. 392), June 1, 1900.

"Seed from single fruit of ornamental shrubby species of *Solanum*, grown in pots in the 'City of the Dead' at Canton. The showy fruits are of an exceedingly deep, rich red color. Plant more or less spiny; 1 foot high; should be grown as a pot plant. (*Fairchild.*)

5156. SOLANUM.

From Canton, China. Received through Messrs. Lathrop and Fairchild (No. 393), June 1, 1900.

"A thorny shrub 2 feet high, grown in pots as an ornamental. The lemon-yellow fruits are distinguished by small manifold enlargements around the base, giving it a most peculiar appearance. Are egg-shaped, 2 or 3 inches long. From the 'City of the Dead' in Canton." (*Fairchild.*)

5157. QUERCUS CORNEA. **Oak.**

From Hongkong, China. Received through Messrs. Lathrop and Fairchild (No. 394), June 1, 1900.

"An edible acorn grown in Hongkong. Tons of this acorn are consumed. It is as sweet as a chestnut and has a flavor which is very agreeable. It deserves serious consideration." (*Fairchild.*)

5158. SCIRPUS TUBEROSA. **Water chestnut.**

From Hongkong, China. Received through Messrs. Lathrop and Fairchild No. 395), June 1, 1900.

"One of the most interesting aquatic vegetables in China. Has been introduced into California by the Chinese. (See reports of California Experiment Station.)" (*Fairchild.*)

5159. ANDROPOGON SORGHUM. **Broom corn.**

From Batavia, Java. Received through Messrs. Lathrop and Fairchild (No. 396), June 1, 1900.

"Red variety, used as an ornamental grass in Batavia. (*Fairchild.*)

5160. TERMINALIA CHEBULA. **Myrobalan.**

From Canton, China. Received through Messrs. Lathrop and Fairchild, June 1, 1900.

"A nut, of which the epicarp is used for a black dye. I am told that this is the *Myrobalan* of India, which is used in large quantities for tanning purposes in the very extensive boot and shoe factories of Cawnpore. Deserves to be looked up. From market in Canton, China. These samples will not grow." (*Fairchild.*)

5161. ORYZA SATIVA. **Rice.**

From Canton, China. Received through Messrs. Lathrop and Fairchild, June 1, 1900.

Grown in Whampoa, near Canton. Distributed.

5162. ORYZA SATIVA. **Rice.**

From Canton, China. Received through Messrs. Lathrop and Fairchild, June 1, 1900.

"This variety is the highest-priced rice in Canton." (*Fairchild.*) Distributed.

5163. ORYZA SATIVA. **Rice.**

From Canton, China. Received through Messrs. Lathrop and Fairchild, June 1 1900.

"Variety grown everywhere about Canton. The common sort." (*Fairchild.*) Distributed.

5164. ORYZA SATIVA. **Rice.**

From Saikong, China. Received through Messrs. Lathrop and Fairchild, June 1, 1900.

"This variety is imported into Canton." (*Fairchild.*) Distributed.

5165. ORYZA SATIVA. **Rice.**

From Bangkok, Siam. Received through Messrs. Lathrop and Fairchild (No. 397), June 1, 1900.

Royal Caw Hluang. "From the private paddy field of the King of Siam. Said to be of superior quality." (*Fairchild.*)

5166. ORYZA SATIVA. **Rice.**

From Bangkok, Siam. Received through Messrs. Lathrop and Fairchild (No. 398), June 1, 1900.

Nasuan. "The largest-kerneled rice in Siam." (*Fairchild.*) Distributed.

5167. PIPER NIGRUM. **Pepper.**

From Bangkok, Siam. Received through Messrs. Lathrop and Fairchild (No. 399), June 1, 1900.

"A variety of white pepper said to be grown exclusively for the table of the King of Siam." (*Fairchild.*)

5168. AVENA SATIVA. **Oat.**

From Proskurow, Russia. Presented by Dr. S. de Mrozinski.

An early oat which ripens within 75 days from the seed. Distributed.

5169. MUSA ABYSSINICA. **Banana.**

From Santa Ana, Cal. Received through Mr. W. T. Swingle, June 1, 1900.

A flowering banana with seeds as large as cacao beans.

5170. VITIS ROTUNDIFOLIA. **Grape.**

From Clarcona, Fla. Presented by Mr. H. Meislahn.

Scuppernong.

5171. VITIS ROTUNDIFOLIA. **Grape.**

From Clarcona, Fla. Presented by Mr. H. Meislahn.

Thomas.

5172. PTÆROXYLON UTILE. **Sneezewood.**

From South Africa. Presented by Hon. A. D. Heywood, Conservator of Forests, Umtata, Cape of Good Hope.

"This tree supplies one of the most durable of South African timbers. Very hard and difficult to work, but valuable for fence posts. Splits easily and burns well." (*Von Mueller.*)

5173. GUAIACUM OFFICINALE. **Lignum-vitæ.**

From Jamaica. Received through Mr. D. G. Fairchild, from the Director, Botanical Department.

"Tree, attaining middle size, but of slow growth. Yields a heavy, diagonally fibrous, somewhat odorous, greenish *lignum-vitæ*, which is unique in its qualities and much sought for pulley blocks, rulers, etc. The resin is used medicinally and for chemical tests." (*Von Mueller.*)

5174. TRIFOLIUM JOHNSONI. **Clover.**

From British East Africa. Presented by the Director of the Royal Botanic Gardens, Kew, England, through the U. S. National Museum.

Seeds of the white clover of the rich, short pastures in the Kiluyu district, at an elevation of 6,500 feet. It is greedily devoured by all sorts of stock and will probably prove most useful in tropical and subtropical countries. Distributed.

5175. GOSSYPIUM BARBADENSE. **Egyptian cotton.**

From Egypt.

5176. ISOPOGON DAWSONI. **Isopogon.**

From New South Wales, Australia. Presented by Mr. R. P. Baker, Curator of the Technological Museum, Sydney.

"A new species of this genus recently described in the Proc. Linn. Soc. N. S. W. It is the tallest of any of the *Isopogons* occurring in eastern Australia. The flowers are more showy than those of other species of the genus." (*Baker.*)

5177. ACTINOTUS HELIANTHUS. **Flannel flower.**

From New South Wales, Australia. Presented by Mr. R. T. Baker, Curator of the Technological Museum, Sydney.

"This is one of the favorite wild flowers of Sydney and at first sight would be taken for a composite, the large, white involucral bracts resembling the ray florets of a composite. It much resembles the *edelweiss* of the Swiss Alps. Grows in poor, sandy, rocky soil." (*Baker.*)

5178. LENS ESCULENTA. **Lentil.**

From Leitmeritz, Bohemia. Received through Messrs. Lathrop and Fairchild, September, 1899.

"Samples of lentils from Leitmeritz, the noted lentil region of Bohemia." (*Fairchild.*)

5179. CUCUMIS METULIFERUS. **African horned cucumber.**

From Avonpark, Fla. Presented by Mr. S. G. Donaldson.

5180. CUCUMIS MELO. **Muskmelon.**

From San Juan, P. R. Presented by Capt. H. R. Lemly, U. S. A., June, 1899.

Valencia. "This melon will keep several months if cut from the vine before fully ripe. It is green in color when ripe and of very fine flavor." (*Lemly.*)

5181. PINUS. **Pine.**

From Russia. Received through Mr. M. A. Carleton, December, 1899.

A pine with edible seeds as large as a coffee berry.

5182. AVENA SATIVA. **Oat.**

From Russia. Received through Mr. M. A. Carleton, 1899.

5183. PAPAVER SOMNIFERUM. **Poppy.**

From Russia. Received through Mr. M. A. Carleton, 1899.

5184. HORDEUM VULGARE. **Barley.**

From Russia. Received through Mr. M. A. Carleton, 1899.

Best for beer-brewing purposes.

5185. SECALE CEREALE. **Rye.**

From Russia. Received through Mr. M. A. Carleton, 1899.

5186. CITRULLUS VULGARIS. **Watermelon.**

From Prim, Ark. Received from Mr. F. P. Hynds, December 14, 1899.

"This melon is a rank grower of surpassing sweetness." (*Hynds.*)

5187. BASELLA RUBRA. **Malabar nightshade.**

From Buenos Ayres, Argentina. Received through Messrs. Lathrop and Fairchild, 1899.

"A very vigorous salad vine; grows over low trellises and forms dense masses of thick, succulent leaves of very crisp texture. These leaves are cooked and make an excellent salad or greens. Introduced into Argentina by General Roca, President of the Republic." (*Fairchild.*)

5188. CASTILLOA ELASTICA. **Rubber.**

From Port Limon, Costa Rica. Presented by Mr. F. C. Nicholas, June 18, 1900.

A lofty forest tree of the bread-fruit family, native of America. Lately introduced into Ceylon and some parts of India. It has been found easy to grow this tree from cuttings and it does well on slopes of hills. Distributed.

5189–5216.

From Manila, P. I. A collection of seeds secured by Lieut. A. P. Hayne, California Heavy Artillery, U. S. V., and Mr. Jeremiah Rebmann, private, Company B, First Nebraska Volunteers, while serving under an honorary commission from the Secretary of Agriculture, during the period from January 7, 1899, to July 1, 1899. The seeds were received January 15, 1900.

5189. Distributed.

5190. CINNAMOMUM.

"An ornamental shrub with very fragrant flowers. Common in Manila." (*Rebmann.*)

5191. CARICA PAPAYA. **Papaw.**

"This is the papaw of the tropics, producing a fine, edible fruit. Common in the Philippines." (*Rebmann.*)

5189–5216—Continued.

5192. Mirabilis.

"A little herbaceous flowering plant cultivated in gardens as an ornamental. Common in Manila." (*Rebmann.*)

5193. Cæsalpinia pulcherrima.

Tagal name, *Caballero* or *Tilor de fuego.*

5194. Areca catechu. **Betel nut.**

Tagal name, *Bonga.*

5195. Calophyllum inophyllum.

Tagal name, *Palo María.*

5196. Albizzia procera.

Tagal name, *Acle.*

5197. Ceiba. **Cotton tree.**

Tagal name, *Taglinao.*

5198. Terminalia latifolia.

Tagal name, *Talisay.*

5199. Gossypium. **Cotton.**

Tagal name, *Bulacana muti.*

5200. Mimosa.

Tagal name, *Ipil.*

5201. Achras sapota. **Sapodillo.**

Tagal name, *Chico.* This tree is an evergreen with dark-green, shining leaves. The fruit is about the size of a hen's egg and much of the same shape, dark-brown, with a mealy surface. It is eaten to a limited extent by the natives.

5202. Anacardium occidentale. **Cashew nut.**

Tagal name, *Cassoy.* A tree 30 to 40 feet high. The gum, sap, bark, and seed are all employed either for dyeing, tanning, or medicine. The fruit is eaten by the natives and the wood used for packing cases, boat building, and charcoal.

5203. Acacia farnesiana. **Cassie.**

Tagal name, *Aroma.* (See No. 3349, Inventory No. 7; and No. 3528, Inventory No. 8.)

5204. Cananga odorata. **Ilang-ilang.**

Tagal name, *Ilang-ilang.* (See No. 3793, Inventory No. 8.)

5205. Sandoricum indicum. **Sandal tree.**

Tagal name, *Santol.* This evergreen glabrous tree is a native of the Moluccas and extensively cultivated in the tropics. Leaves trifoliate and numerous; flowers yellow, sparse, and glomerate. The apple-shaped fruit is fleshy, acid, and edible.

5206. Spondias dulcis. **Ciruela.**

Tagal name, *Sirihuelas.* A tree from 50 to 60 feet high. The deep-amber colored fruit is egg-shaped, measures a foot in circumference, and weighs 1 or more pounds. The rind tastes of turpentine, but the pulp has an apple-like smell and an agreeable flavor.

5189-5216—Continued.

5207. POINCIANA REGIA. **Royal poinciana.**

Tagal name, *Árbol de fuego* (fire tree). This is a beautiful ornamental tree. It is especially desirable for streets and parks. (See No. 808, Inventory No. 1.)

5208. CARYOTA URENS. **Fish-tail palm.**

One of the finest ornamental palm trees. It is one of the hardiest varieties known, growing in the Himalayas at an altitude of 5,000 feet. Some claim that it will grow at an altitude of 7,500 feet, where the temperature sometimes approaches the freezing point.

5209. SESBANIA GRANDIFLORA.

Tagal name, *Caturay.* Called in Australia the corkwood tree. Valuable for various purposes. The red-flowered variety is very ornamental. The fruit sometimes attains a length of 3 feet.

5210. ANONA RETICULATA. **Custard apple.**

Tagal name, *Anonas.* A small tree, the leaves of which are used in dyeing and tanning, the bark for medicine and fiber, and the fruit as a food. The timber also has commercial value.

5211. STERCULIA HELICTERES.

Tagal name, *Dungan.* (See No. 3804, Inventory No. 8.) Distributed.

5212. ACACIA.

Tagal name, *Acacia.*

5213. TABERNÆMONTANA PANDACAQUI. Distributed.

5214. ARTABOTRYS ODORATISSIMUS.

Tagal name, *Ilang-ilang de China.*

5215. POINCIANA REGIA. **Royal poinciana.**

Tagal name, *Árbol de fuego.* (See No. 5207.)

5216. CITRUS DECUMANA. **Pomelo.**

Tagal name, *Naranja.* Red-fleshed. Bears fruit throughout the year. (See No. 3409, Inventory No. 8.)

5217. COLA ACUMINATA. **Kola nut.**

From Jamaica. Received June 30, 1900.

An African tree growing to a height of from 30 to 60 feet and containing many valuable properties. The plant resembles the chestnut, and is especially adapted to low, damp lands, but can be grown at an altitude of 1,000 feet. It is easily cultivated and yields a large crop twice a year. It begins to fruit when 4 or 5 years old. The large trees bear flowers and fruit at the same time. The nut is used in making a beverage which is considered by some to be superior to coffee or cocoa. Distributed.

5218. ASPARAGUS HORRIDUS.

From Algeria. Received through Mr. W. T. Swingle, June 30, 1900.

A wild species considered by some to be superior to the best cultivated asparagus. Distributed.

5219. CARICA PAPAYA. **Papaw.**

From Mexico. Presented by Mr. J. Lawton Taylor, of Santa Cruz de Alaya, Sinaloa, June 30, 1900.

Hawaiian. "An immensely productive variety. It bears crops several times during the year." (*Taylor.*)

5220. CARICA PAPAYA. **Papaw.**

From Mexico. Presented by Mr. J. Lawton Taylor, of Santa Cruz de Alaya, Sinaloa, June 30, 1900.

Mexican. "This tree bears only one crop of fruit during the season." (*Taylor.*)

5221. LUFFA ACUTANGULA. **Gourd.**

From Mexico. Presented by Mr. J. Lawton Taylor, of Santa Cruz de Alaya, Sinaloa, June 30, 1900.

Saqua. "A native of Asia. Eaten cooked as a vegetable or raw." (*Taylor.*) (See No. 5122.)

5222. VIGNA CATJANG. **Cowpea.**

From Mexico. Presented by Mr. J. Lawton Taylor, of Santa Cruz de Alaya, Sinaloa, June 30, 1900.

Ankok. "A black climbing bean, a native of Asia. It makes a good arbor for grapes. The pods grow here to a length of 40 inches. They are tender and are eaten like string beans." (*Taylor.*) (See No. 5118.)

5223. MOMORDICA CHARANTIA. **Gourd.**

From Mexico. Presented by Mr. J. Lawton Taylor, of Santa Cruz de Alaya, Sinaloa, June 30, 1900.

Laqua. "A kind of gherkin, cooked with roast meat." (*Taylor.*) (See No. 5121.)

5224. PHŒNIX DACTYLIFERA. **Date.**

From Cora, near Biskra, Algeria. Received through Mr. W. T. Swingle (No. 2), July 2, 1900.

Ksiba.

5225–5341. PHŒNIX DACTYLIFERA. **Date.**

A collection of date palms obtained by Mr. W. T. Swingle in northern Africa, to be described in a separate publication.

5342. TRITICUM VULGARE. **Wheat.**

From Tokyo, Japan. Received July 5, 1900.

Onigara. An early ripening, soft, bearded wheat, rather hardy, and with a fair gluten content. Is of yellowish-green color in the autumn. Grain of medium size, light-brown; straw tall, erect; a fair stooler

5343. TRITICUM VULGARE. **Wheat.**

From Tokyo, Japan. Received July 5, 1900.

Yemide. An early-ripening, bearded winter wheat with very large, coarse, erect straw. Grain of medium size, soft, and light-brown in color.

5344. CRYPTOMERIA JAPONICA. **Cryptomeria.**

From Yokohama, Japan. Received July 5, 1900.

A very beautiful Japanese evergreen. Distributed.

5345. BAMBUSA. **Bamboo.**

From Yokohama, Japan. Received July 5, 1900.

Matake. Distributed.

5346. BAMBUSA. **Bamboo.**

From Yokohama, Japan. Received July 5, 1900.

Moso. Distributed.

5347. ERIOBOTRYA JAPONICA. **Loquat.**

From Italy. Received July 5, 1900. (See Nos. 4566 and 4567.) Distributed.

5348. BROMUS UNIOLOIDES RUPESTRIS. **Rescue grass.**

From La Plata, Argentina. Received through Messrs. Lathrop and Fairchild, July 14, 1900. Presented by Dr. Carlos Spegazzini. Distributed.

5349. LOLIUM BRASILIANUM. **Rye grass.**

From La Plata, Argentina. Received through Messrs. Lathrop and Fairchild, July 14, 1900. Presented by Dr. Carlos Spegazzini. Distributed.

5350. CEREUS CHALIBÆUS.

From La Plata, Argentina. Received through Messrs. Lathrop and Fairchild, July 14, 1900. Presented by Dr. Carlos Spegazzini. (See No. 3424, Inventory No. 8.)

5351–5355. TRITICUM DURUM. **Wheat.**

From Marseille, France. Received through Mr. W. T. Swingle, July 18, 1900.

"These five numbers comprise a collection of the different types of macaroni wheat for sale at the Marseille stock exchange June 17, 1900. They were procured through the kindness of Dr. Bendit after consultation with many of the wheat brokers and millers of Marseille." (*Swingle.*)

5351. BERDEANSKA.

5352. NOVOROSSISK.

5353. ALGERIAN.

5354. ARGENTINE.

5355. TAGANROG.

5356. RAPHANUS SATIVUS. **Radish.**

From Kagoshima, Japan. Presented by Mr. T. Okohira, of the Japanese Legation. Received July 16, 1900.

Daikon. (See No. 3876, Inventory No. 8.)

5357–5359. ARACHIS HYPOGÆA. **Peanut.**

From Marseille, France. Received through Mr. W. T. Swingle, July 28, 1900.

A collection of the best oil varieties of peanuts, purchased in the Marseille market by the United States consul. They are as follows:

5357. From Senegal.

5358. *Gambia.*

5359. *Coromandel.*

5360. PHORMIUM TENAX EGMONTIANA. **New Zealand flax.**

From New Brighton, Canterbury, New Zealand. Received July 30, 1900. Presented by Mr. L. Cockayne.

The brown or purple leaved New Zealand flax. Distributed.

5361. PHORMIUM COOKIANUS. **New Zealand flax.**

From New Brighton, Canterbury, New Zealand. Received July 30, 1900. Presented by Mr. L. Cockayne.

A form growing on limestone rocks at sea level. Distributed.

5362. ORYZA SATIVA. **Rice.**

From Java. Received through Messrs. Lathrop and Fairchild, July 30, 1900.

A small sample of the most noted Javan rice, the *Indra Mayoe*, secured from the Holland exhibit at the Paris Exposition, 1900. Distributed.

5363. CUCURBITA MAXIMA. **Pumpkin.**

From Forestburg, S. Dak. Received August 2, 1900. Presented by Hon. H. C. Warner.

Hungarian honey. Seed grown at Forestburg two years from the original No. 14, Inventory No. 1, imported by Prof. N. E. Hansen.

5364. ATRIPLEX NUMMULARIA. **Old man saltbush.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900. (See No. 5082.)

5365. ATRIPLEX HALIMOIDES. **Saltbush.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900. (See No. 5083.)

5366. ATRIPLEX LEPTOCARPA. **Saltbush.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900.

A much-branched trailing perennial. The whole plant is covered with glaucous bloom. The leaves are very variable in shape, but mostly oblong, and from 1 to 2 inches in length. The fruit is small, narrow, cylindrical, and prominently two-pointed at the apex. This species was introduced into California in 1891 and has become widely distributed. (See Farmers' Bulletin No. 108.) Distributed.

5367. ATRIPLEX ANGULATA. **Saltbush.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900.

"A dwarf shrubby plant with spreading branches more or less covered with a mealy whiteness. It withstands very dry weather, is easily cultivated, and makes a valuable hay for feeding stock. The seeds should be sown in early autumn, after a rainfall." (*Turner.*) Distributed.

5368. ATRIPLEX VESICARIA. **Bladder saltbush.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900.

An erect, bushy shrub, 18 inches to 2 feet high, and covered with a white, scaly dust. The leaves are about three-fourths of an inch long and oblong in shape. The fruit is membranous, with large, inflated, angled, bladder-like appendages on each side, hence the name "bladder saltbush." In Australia this species is considered one of the most valuable forage plants, because of the abundance of seed which it produces and the ease with which the seeds are spread about. It withstands the utmost extremes of drought. (See Farmers' Bulletin No. 108.)

5369. ATRIPLEX LEPTOCARPA. **Saltbush.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900. Distributed.

(See No. 5366.)

5370. ASTREBLA TRITICOIDES. **Mitchell grass.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock August 3, 1900.

A perennial grass found on rich soils.

5371. ASTREBLA PECTINATA. **Mitchell grass.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900.

This is one of the famous Mitchell grasses and is regarded by some as the best of all native grasses, both for its drought enduring qualities and for its fattening properties. Distributed.

5372. ERAGROSTIS PILOSA. **Love grass.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900.

This grass is common in the warm and temperate regions of the northern hemisphere, chiefly in the Old World. When conditions are favorable it grows about 3 feet high. It reproduces itself from falling seeds and often grows during the entire winter. Little attention is required in its cultivation. Distributed.

5373. DIPLACHNE FUSCA. **Swamp grass.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900.

This annual grass grows plentifully in damp and swampy places and is worth cultivating on low-lying waste lands. It makes desirable hay and ensilage. The plant produces an abundance of seeds which ripen late in the winter.

5374. ENCHYLÆNA TOMENTOSA. **Barrier saltbush.**

From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900.

This procumbent or divaricately branched undershrub has been cultivated for many years and produces seed nearly all the year round, but more abundantly in the summer months. Owing to its free seeding and the easy germination of its seed, it grows quite plentifully. Sheep feed greedily on this shrub. The seeds should be sown during the early autumn months, after a rainfall, if possible. Distributed.

5375. CHÆTOCHLOA.

From Roebourne, West Australia. Presented by Mr. W. D. Cusack, August 3, 1900.

An annual grass affording good feed.

5376. CYDONIA SINENSIS. **Chinese quince.**

From Washington, D. C. Presented by Mr. Henry F. Blount, August 10, 1900.

5377. CASTILLOA ELASTICA. **Rubber.**

From Managua, Nicaragua. Received August 10, 1900. Distributed.

5378. LACTUCA ACUMINATA. **Wild lettuce.**

From Kerrsville, Tex. Presented by Mr. E. K. Carr, August 13, 1900.

"This plant grows wild in sheltered places and will endure a temperature of zero, Fahrenheit. Never known by oldest settlers to be cultivated. It commences to grow with the fall rains and makes an excellent winter salad, being free from a bitter taste. It is eaten greedily by cattle. Is never found on open ranges." (*Carr.*) Distributed.

5379. Astragalus crassicarpa. **Ground plum.**

From Kerrsville, Tex. Presented by Mr. E. K. Carr, August 13, 1900.

This is a perennial legume, which grows throughout the entire prairie region. It is well known on account of its fleshy plums or pods, which are produced in the greatest abundance during the early spring months. The forage is rich and is relished by all kinds of stock. There are several closely related species, which are all equally useful, and an effort should be made to prevent their complete extermination, at least until something equally good is found to take their places. Distributed.

5380. Triticum durum. **Wheat.**

From Mustapha-Alger, Algeria. Received through Mr. W. T. Swingle, August 14, 1900.

Pellissier.

5381. Hevea pauciflora. **Rubber.**

From Georgetown, British Guiana. Presented by Prof. J. B. Harrison, through Dr. H. W. Wiley, Chemist. Received August 15, 1900. Distributed.

5382. Hevea confusa. **Rubber.**

From Georgetown, British Guiana. Presented by Prof. J. B. Harrison, through Dr. H. W. Wiley, Chemist. Received August 15, 1900. Distributed.

5383. Physalis violacea.

From Los Angeles, Cal. Presented by Mr. Elmer Stearns, August 24, 1900.

"Various species of Physalis are always to be seen in the Mexican markets. The fruits are called 'tomatoes' and are used to make a dressing for meats, etc., or are combined with red peppers to make a chili sauce." (*Rose.*) Distributed.

5384-5392.

From Mount Lindhurst, South Australia. Received August 28, 1900.

A collection of seeds of some of the native forage plants of this region, secured by Mr. Max Koch.

5384. Clianthus dampieri. **Sturt's desert pea.**
5385. Acacia cibaria. Distributed. **Mulga.**
5386. Polycalymnia sturtii.
5387. Lavatera plebeia. **Marshmallow.**
5388. Trigonella suavissima. **Scented clover.**
5389. Erodium cygnorum. **Geranium.**
5390. Gossypium sturtii.
5391. Helipterum polygalifolium.
5392. Kochia sedifolia. **Bluebush.**

5393. Nicotiana tabacum. **Tobacco.**

From Cuba. Received August 23, 1900.

True Havana.

5394-5457.

From Calcutta, India. A collection of seeds of Indian economic plants presented by Prof. D. Prain, Superintendent Royal Botanic Garden. Received August 30, 1900.

5394. Æschynomum cannabina.
5395. Amaranthus polygamus. Distributed. **Amaranth.**
5396. Anethum sativa. Distributed. **Fennel.**

5394–5457—Continued.

5397.	Arachis hypogæa.	Peanut.
5398.	Basella alba.	Malabar nightshade.
5399.	Benincasa cerifera.	Wax gourd.
5400.	Cajanus indicus. Distributed.	Dâl.
5401.	Canavalia gladiata.	Knife bean.
5402.	Canavalia virosa.	Knife bean.
5403.	Capsicum frutescens.	Bird pepper.
5404.	Cicer arietinum.	Garbanzo.
5405.	Citrullus vulgaris.	Watermelon.
5406.	Corchorus olitorius.	Jute.
5407.	Coriandrum sativum.	Coriander.
5408.	Cucumis sativus.	Cucumber.
5409.	Cucumis utilissimus.	
5410.	Cucurbita pepo.	Squash.
5411.	Cuminum cyminum.	Cumin.
5412.	Dolichos lablab. *Falcatum majus.*	Madagascar bean.
5413.	Dolichos lablab. *Falcatum minus.*	Madagascar bean.
5414.	Dolichos lablab. *Purpurascens.*	Madagascar bean.
5415.	Vigna catjang (red).	Cowpea.
5416.	Vigna catjang (white).	Cowpea.
5417.	Eleusine coracana.	Ragi millet.
5418.	Ervum hirsutum.	Lentil.
5419.	Ervum lens.	Lentil.
5420.	Fœniculum vulgare.	Fennel.
5421.	Hibiscus esculentus.	Okra.
5422.	Indigofera tinctoria.	Indigo.
5423.	Lagenaria vulgaris.	Gourd.
5424.	Lathyrus sativus.	Bitter vetch.
5425.	Linum usitatissimum.	Flax.
5426.	Luffa acutangula.	Dish-rag gourd.
5427.	Luffa pentandra.	Gourd.
5428.	Momordica charantia.	Gourd.
5429.	Momordica muricata.	Gourd.
5430.	Nigella sativa.	Fennel flower.
5431.	Panicum italicum.	Millet.
5432.	Panicum miliaceum.	Broom-corn millet.
5433.	Papaver somniferum.	Poppy.
5434.	Pennisetum spicatum.	Pearl millet.
5435.	Phaseolus aureus.	Bean.
5436.	Phaseolus max.	Bean.
5437.	Phaseolus mungo.	Green gram.

5394–5457—Continued.

5438.	Phaseolus pilosus.	**Bean.**
5439.	Phaseolus roxburghii.	**Bean.**
5440.	Physalis peruviana.	**Ground cherry.**
5441.	Plantago ispaghula.	
5442.	Ptychotis ajowan.	
5443.	Raphanus sativus.	**Radish.**
5444.	Sesamum indicum.	**Sesame.**
5445.	Sinapis dichotoma.	
5446.	Solanum melongena.	**Egg plant.**
5447.	Suæda maritima.	
5448.	Trichosanthus anguina.	
5449.	Trigonella corniculata.	
5450.	Trigonella fœnum-græcum.	**Fenugreek.**
5451.	Triticum vulgare. Distributed.	**Wheat.**
5452.	Zea mays.	**Corn.**
5453.	Amaranthus polygamus.	
5454.	Crotalaria juncea.	**Sunn-hemp.**
5455.	Panicum colonum.	
5456.	Phaseolus aconitifolius.	
5457.	Carthamus tinctorius. Distributed.	

5458. SECALE CEREALE. **Rye.**

From London, Ontario. Presented by Darch & Hunter, August 31, 1900. *Thousandfold.*

5459. SECALE CEREALE. **Rye.**

From London, Ontario. Presented by Darch & Hunter, August 31, 1900. *Giant Winter.*

5460. TRITICUM VULGARE. **Wheat.**

From London, Ontario. Presented by Darch & Hunter, August 31, 1900. *Diamond Grit.*

5461. TRITICUM VULGARE. **Wheat.**

From London, Ontario. Presented by Darch & Hunter, August 31, 1900. *Canadian Pearl.*

5462. TRITICUM VULGARE. **Wheat.**

From London, Ontario. Presented by Darch & Hunter, August 31, 1900. *Paramount.*

5463. TRITICUM VULGARE. **Wheat.**

From London, Ontario. Presented by Darch & Hunter, August 31, 1900. *Gold Coin.*

5464. TRITICUM VULGARE. **Wheat.**

From Argentina. Received September 1, 1900.

Chubut. This variety comes from the valley of the Chubut River, in southern Argentina. It is a semihard, red-grained wheat of very good quality. It is probably the best wheat for bread flour in South America. It is best known as a winter wheat, but will probably not stand our hard winters north of the thirty-fifth parallel. It should be sown about March 1.

5465. TRITICUM DURUM. **Wheat.**

From Argentina. Received September 1, 1900.

Candeal. This wheat is rather commonly grown in Chile and Argentina. It has long, compact, bearded heads, and yellowish-white, hard grains. It will probably be resistant to drought and to orange-leaf rust. Adapted for growing in dry, hot districts, such as west Texas and the drier portions of Colorado, Kansas, and Oklahoma. South of the thirty-fifth parallel it should be grown as a winter wheat, sown October 15 to November 15. North of this line it will probably not stand the winter and should be sown February 15 to March 1.

5466. TRITICUM VULGARE. **Wheat.**

From Argentina. Received September 1, 1900.

Francés. This variety is a soft or semihard, reddish-grained wheat, originally introduced into Argentina from France. It is a bald variety of only fair milling quality and not at all hardy. It is adapted for trial in the Southern States. Should be sown in October. It is one of the two chief varieties of all Argentina.

5467. TRITICUM VULGARE. **Wheat.**

From Argentina. Received September 1, 1900.

Barletta. A bearded winter variety. Chaff brown to black, smooth; beards very strong and ordinarily divergent; grain soft, red to amber; head rather loose and flattish; straw partially full.

5468. TRAPA BICORNIS. **Horn chestnut.**

From China. Seed purchased in the Chinese market, San Francisco, Cal. Received September 1, 1900.

5469. CASSIA FISTULA.

From Honolulu, H. I. Presented by Prof. Wm. C. Stubbs. Received September 4, 1900.

This tree can be grown in all tropical countries.

5470. CITRUS LIMONUM. **Lemon.**

From Honolulu, H. I. Presented by Prof. Wm. C. Stubbs. Received September 4, 1900.

5471. AVENA SATIVA. **Oat.**

From Svalof, Sweden. Received through Messrs. Lathrop and Fairchild (No. 453), March 11, 1901.

Ligowo. "A pedigreed variety, selected by the Seed Breeding Institute of Svalof, which has been very well received in Sweden, Russia, Germany, and Belgium. It possesses an unusually full, white kernel, making it especially adapted for the manufacture of oatmeal. It is earlier and possesses a stronger straw than the varieties generally grown in Sweden. It is of remarkable uniformity and a heavy yielder." (*Fairchild.*) Distributed.

5472. HORDEUM DISTICHUM ERECTUM. **Barley.**

From Svalof, Sweden. Received through Messrs. Lathrop and Fairchild (No. 450), March 11, 1901.

Princess. "A pedigreed variety, originated on the Seed Breeding Society's grounds and grown in quantity by the General Swedish Limited Seed Company of Svalof. It was selected from trial plots of the variety 'Prentice' and is characterized by an especially strong straw and an excellent quality of grain. It is remarkably well suited for heavy clay soils of a wet character. It deserves a thorough trial in all regions where the soil is heavy or wet and there is danger of the grain falling." (*Fairchild.*)

5473. HORDEUM DISTICHUM NUTANS. **Barley.**

From Svalof, Sweden. Received through Messrs. Lathrop and Fairchild (No. 451), March 11, 1901.

Chevalier II. "A pedigreed variety, selected by Dr. Nillsson from 'Horsford Chevalier.'" (*Fairchild.*)

5474. HORDEUM DISTICHUM ERECTUM. **Barley.**

From Svalof, Sweden. Received through Messrs. Lathrop and Fairchild (No. 472), March 11, 1901.

Svanshals. "A very early ripening variety, pedigreed at the Seed Breeding Institute of Svalof. It is suited to cold, wet, and even swampy land. Not comparable with No. 5472 or No. 5473 as a brewers' barley. Worthy of trial in a similar climate in America." (*Fairchild.*)

5475. VICIA SATIVA TYPICA. **Sweet vetch.**

From Svalof, Sweden. Received through Messrs. Lathrop and Fairchild (No. 454), March 11, 1901.

Foradlade Sotvicker. "A pedigreed variety, bred by the Seed Breeding Society of Svalof, Sweden. The seeds of this vetch are much heavier than those of ordinary varieties and the yield of seed surer and larger. This variety has just come on the market and the supply is limited." (*Fairchild.*)

5476. VICIA SATIVA TYPICA. **Gray vetch.**

From Svalof, Sweden. Received through Messrs. Lathrop and Fairchild (No. 455), March 11, 1901.

Foradlade Gravicker. "A pedigreed variety selected by the Seed Breeding Society of Sweden and characterized by much heavier seeds and very much larger yield of seed than the ordinary variety." (*Fairchild.*)

5477. (Blank.)

5478. CASTILLOA ELASTICA. **Rubber.**

From Heneratgoda, Ceylon. Presented by J. P. William & Bros. Received September 6, 1900.

Cervantes. (See Nos. 5188 and 5377.) Distributed.

5479. HEVEA BRASILIENSIS. **Para rubber.**

From Heneratgoda, Ceylon. Presented by J. P. William & Bros. Received September 6, 1900. Distributed.

5480. LILIUM HARRISSII. **Easter lily.**

From Bermuda. Received September 5, 1900. Distributed.

5481. VACCINIUM VITIS IDÆA. **Cranberry.**

From Kiovikko, Finland. Received through Messrs. Lathrop and Fairchild (No. 438), September 10, 1900.

"A wild cranberry from the moors of North Finland. This species, so far as I can learn, has never been cultivated in Sweden and Finland. It is, however, of considerable commercial importance and many carloads of the fruit are shipped yearly to Germany. The berries are one-fourth as large as those of *V. macrocarpon*, but Europeans claim they are more aromatic." (*Fairchild.*) Distributed.

5482. RUBUS CHAMÆMORUS. **Raspberry.**

From Kiovikko, above Uleåborg, Finland. Received through Messrs. Lathrop and Fairchild (No. 440), September 10, 1900.

"An orange-fruited Arctic raspberry, the English name of which is unknown to me. In Finland the fruits of this species are dried and kept for months. They have a peculiar acid taste, highly appreciated. Never cultivated in Finland. A true moor plant, suitable only for Alaskan moors." (*Fairchild.*) Distributed.

5483. RUBUS ARCTICUS. **Arctic raspberry.**

From Uleåborg, Finland. Received through Messrs. Lathrop and Fairchild (No. 439), September 10, 1900.

"A wild arctic and subarctic plant which is very abundant on the moors. It is nowhere cultivated and may be very difficult to grow from seed. The only region where it might succeed is Alaska, where, presumably, the same species occurs. The fragrance of these Finnish berries is something delicious, and in Sweden and Finland exceptionally fine jam is made from them." (*Fairchild.*) Distributed.

5484. LUPINUS ALBUS. **White lupine.**

From France. Received September 14, 1900.

The white lupine is an excellent green-manure crop and winter soil cover. The seed should be sown by October 1, in time for the early rains and while the ground is yet warm. The crop should be plowed under when the lupines are in blossom." (*Hilgard.*)

5485. RUBUS ARCTICUS. **Arctic raspberry.**

From Abo, Finland. Received through Messrs. Lathrop and Fairchild (No. 424), September 12, 1900.

"A wild species growing in the swamps of northern Finland especially. The fruit is orange yellow, with a red blush, and has a refreshing flavor. This plant is not cultivated in Finland, but is highly prized for preserves. Should be sown in moss or very moist soil." (*Fairchild.*) (See No. 5483.) Distributed.

5486. TRITICUM VULGARE. **Wheat.**

From Ithaca, N. Y. Presented by Prof. I. P. Roberts, Director of the Cornell Experiment Station. Received September 12, 1900.

Dawson's Golden Chaff. "Under very unfavorable conditions and a winter so severe that there was almost an entire failure of wheat on the surrounding farms, this wheat yielded 41 bushels per acre." (*Roberts.*)

5487. ALLIUM CEPA. **Onion.**

From Woodhaven, N. Y. Presented by Mr. H. Beaulieu, seedsman and florist, September 6, 1900.

"A white onion, hardy in New York, which will stand the coldest weather without protection. Sow from August 15 to September 15. Comes about three weeks earlier than the sets and does not go to seed the first year. Similar in color and shape to the White Portugal, but much earlier." (*Beaulieu.*)

5488. CYPHOMANDRA BETACEA. **Tree tomato.**

From Ceylon. Received through Messrs. Lathrop and Fairchild, September 19, 1900.

"This species has been introduced into Ceylon very extensively from the West Indies and has proven a great success. It is used by many European families and is a very palatable fruit." (*Fairchild.*) (See Nos. 5112, 5115, 5116, 5191, 5219, and 5220.)

5489. CARICA PAPAYA? **Papaw.**

From Ceylon. Received through Messrs. Lathrop and Fairchild.

"A very interesting species which I was not able to determine, but which is cultivated quite extensively in the mountain regions of Ceylon, which are subject to occasional frosts. The plants are, therefore, hardier than the ordinary *Carica papaya* and should be widely distributed in Florida. The fruits of this species are much smaller than the ordinary *Carica*, but are very much relished by the natives and are often eaten by Europeans. They have a refreshing acid flavor quite different from that of the ordinary species. For papayin extraction this species may prove valuable." (*Fairchild.*) Distributed.

5490. LINUM USITATISSIMUM. **Flax.**

From Paris, France. Received through Messrs. Lathrop and Fairchild, September 19, 1900.

Specimen furnished by the Stockholm Economic Museum. Reported to be seed grown in Sweden, and therefore may prove hardier than varieties grown farther south." (*Fairchild.*)

5491. ROSA CANINA. **Wild rose.**

From Sweden. Received through Messrs. Lathrop and Fairchild, September 19, 1900. (See No. 880, Inventory No. 1.) Distributed.

5492. TRITICUM DURUM. **Wheat.**

From France. Received October 12, 1900.

Medeah. This wheat is from stock selected and grown by Vilmorin-Andrieux & Cie., of Paris. It is suitable for fall planting in the South or spring planting in the North. It is heavily bearded, with a smooth, brown chaff, small but rather strong, solid straw, and very hard, light-amber colored grain. It is one of the best-known varieties of the hard French wheats, and, although not especially valuable for bread making, is a heavy yielder, and is particularly adapted for macaroni manufacture. Distributed.

5493. TRITICUM VULGARE. **Wheat.**

From Collegepark, Md. Received September 21, 1900.

Fultz. A winter wheat grown at the Maryland Agricultural College.

5494. CUCUMIS.

From Tiger Mill, Tex. Received September 25, 1900. Presented by Mr. H. T. Fuchs.

Genuine Field Pomegranate. "Very fine eating, either raw or cooked." (*Fuchs.*)

5495. CITRULLUS VULGARIS. **Watermelon.**

From Tiger Mill, Tex. Received September 25, 1900. Presented by Mr. H. T. Fuchs.

Best of All. Distributed.

5496. Triticum vulgare. **Wheat.**

From Budapest, Austria-Hungary. Received September 27, 1900.

Banat.

5497. Triticum vulgare. **Wheat.**

From Budapest, Austria-Hungary. Received September 27, 1900.

Theiss.

5498. Triticum vulgare. **Wheat.**

From Budapest, Austria-Hungary. Received September 27, 1900.

Bacska.

5499. Triticum vulgare. **Wheat.**

From Budapest, Austria-Hungary. Received September 27, 1900.

Weissenburg.

5500. Triticum vulgare. **Wheat.**

From Budapest, Austria-Hungary. Received September 27, 1900.

Pesterboden.

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN No. 6.
B. T. GALLOWAY, Chief of Bureau.

A LIST

OF

AMERICAN VARIETIES OF PEPPERS.

BY

W. W. TRACY, Jr., Assistant,
BOTANICAL INVESTIGATIONS AND EXPERIMENTS.

Issued February 1, 1902.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., November 6, 1901.

SIR: I transmit herewith a manuscript submitted from the Office of the Botanist of a paper entitled A List of American Varieties of Peppers, by W. W. Tracy, jr., and respectfully recommend that it be published as Bulletin No. 6 of this Bureau.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

In the Yearbook of the Department of Agriculture for 1901 it is stated that American seedsmen catalogued the preceding year "685 real or nominal varieties of cabbage, 320 of table beets, 340 of sweet corn, 560 of bush beans, 255 of pole beans, 320 of cucumber, 530 of lettuce, and an equally large number of varieties of other vegetables."[a]

In such a maze of names, a large proportion of which are accompanied by the most meager descriptions, the progressive cultivator, endeavoring to ascertain what varieties are best adapted to his particular location, soil, climate, and uses, has little to guide him. Among seedsmen, also, similar difficulties exist. A small number of the larger houses maintain extensive trial grounds, but the information secured in this way is usually not made public. There remains a strong demand, both from the seed trade and from the public, for more precise information about the qualities of the various advertised varieties—information which can be furnished only after years of careful study and experimentation. There is one necessary preliminary to such work, namely, a catalogue of the names of the varieties.

There is no published work which gives all the varieties of vegetables sold by American seedsmen, and the Department of Agriculture has therefore prepared such a list, which is now in manuscript. It has seemed desirable to publish experimentally a minor portion of this list, and for that purpose the peppers have been selected.

The list has been prepared by Mr. W. W. Tracy, jr., who has charge of the Department's variety testing, with the aid of Mr. J. E. W. Tracy, his assistant.

Frederick V. Coville,
Botanist.

Office of the Botanist,
Washington, D. C., November 6, 1901.

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[a] In counting the number of these varieties, names were included which differed from others simply by the addition of a descriptive word, such as "improved," "large," "early," or the names of persons, while other varieties, having attached to them unimportant descriptive words, such as "select," "new," and "choice," were not included.

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A LIST OF AMERICAN VARIETIES OF PEPPERS.

INTRODUCTION.

One great source of the confusion in variety names which this list is designed to help in overcoming is the use of descriptive words and phrases in multiplying names which frequently mark no real varietal differences. Among peppers this is not carried so far as elsewhere, and the examples which can be cited are not as striking as in case of some of the more generally grown vegetables. The most notable examples are found in Ruby King, which different seedsmen catalogue as follows: Burpee's Ruby King, Maule's Ruby King, Maule's Improved Ruby King, Bolgiano's Mammoth Ruby King, Mammoth Ruby King; and in Bell, which is listed under the following names: Large Bell, Improved Large Bell, Sweet Bell, Large Sweet Bell, Large Red Bell, Mammoth Bell. In case of some other vegetables there is such an indiscriminate use of epithets as to make the distinctions in varieties very bewildering. Of Jersey Wakefield cabbage, for example, the following names are used by different seedsmen merely to distinguish their stocks: Hawkin's Jersey Wakefield, Tait's Early Jersey Wakefield, Rice's Early Jersey Wakefield, Wood's Selected Early Jersey Wakefield, Maule's Prize Wakefield, Our Own Jersey Wakefield, Extra Choice Early Jersey Wakefield, Pedigree Jersey Wakefield, Extra Select Jersey Wakefield, Improved Early Jersey Wakefield, etc.

Occasionally these descriptives mark real superiority of stock, especially in point of purity; but it would be much better if such superiority were left to be known from the reputation of the seed house rather than advertised by the addition of the seedsman's name or of adjectives to the simple variety name, both of which usages have been so much abused as to have little or no significance.

Sometimes, however, words attached to the simple variety name, or other slight differences in names, do indicate real differences in type. Examples are: Philadelphia Dutch Butter, Philadelphia Butter, and Maule's Philadelphia Butter, names applied to varieties of lettuce of types quite different from each other, as are also the names Favorite, Rudolph's Favorite, Sutton's Favorite, Florida Favorite, and the Gardener's Favorite.

In preparing this list of varieties the following words have been omitted from the variety names: Improved, extra, perfected, pedigree, select, selected, extra select, choice, extra choice, superior, celebrated, fine, famous, our, our own, true, new, the, and the names of persons. Exceptions have been made and some of the above words retained, where a personal name or a descriptive word is known to indicate a real difference in type, or where the dropping of such a word would be confusing and misleading because the variety is so universally known and recognized only by the full name, as in Procopp's Giant pepper. The words giant, mammoth, large, early, and extra early have in every case been retained because, though not usually indicating a difference in type, there are many cases where they do indicate such a difference. There is, perhaps, more reason for retaining the words "improved" and "perfected" and the names of persons than the other words mentioned above as omitted, and for this reason these words have been allowed to stand in the groups of similar names given in the list, though, as already stated, they have been omitted from the alphabetical arrangement.

The present list of peppers includes all the varieties catalogued by seedsmen in the United States and Canada for the year 1901. After each variety name are given abbreviations of the name of the seedsmen who catalogue the variety. Whenever similar names exist these are also given. By "similar names" are meant resembling names given by different seedsmen, whether to like or unlike varieties. In some cases such varieties are dissimilar in type or essential characters. Most of them, however, are similar or identical in this regard, and sometimes they are so in the matter of purity of stock also. The synonyms cited are those given by seedsmen in their own catalogues for the year 1901. Some of the names given as synonyms are undoubtedly incorrect, but this is due usually to a local misunderstanding of the generally recognized type or to a misapplication of names rather than to a lack of knowledge of the characteristics of the varieties themselves.

LIST OF ABBREVIATIONS OF NAMES OF SEEDSMEN.

The following are the abbreviations, alphabetically arranged, which have been adopted to designate the seedsmen referred to in this bulletin. The list includes, so far as is known, all the seedsmen of the United States and Canada who issued catalogues or price lists for the year 1901:

Agn	H. C. & J. B. Agnew, Agnew, Cal.
AGT	A. G. Tillinghast, Laconner, Wash.
All	John H. Allan Seed Co., Three Mile Bay, N. Y.
Alr	Alneer Bros., Rockford, Ill.
Alx	Alexander Seed Co., Augusta, Ga.
Anb	E. Annabil, McPherson, Kans.
Ans	A. H. Ansley & Sons, Milo Center, N. Y.

Ar	L. E. Archias Seed Co., Carthage, Mo.
Bai	Bailey & Sons, Salt Lake City, Utah.
Bak	Baker Bros., Fort Worth, Tex.
Bdg	Alfred Bridgeman, New York, N. Y.
Bel	J. J. Bell, Deposit, N. Y.
Ber	A. A. Berry Seed Co., Clarinda, Iowa.
Bgg	B. L. Bragg Co., Springfield Mass.
Bgs	Briggs Brothers & Co., Rochester, N. Y.
Bkt	W. C. Beckert, Allegheny, Pa.
Blg	F. W. Bolgiano, Washington, D. C.
Bng	William H. Brunning, Rahway, N. J.
Bou	William A. Bours & Co., Jacksonville, Fla.
Bow	E. J. Bowen, San Francisco, Cal.
Brb	E. W. Burbank Seed Co., Fryeburg, Me.
	Luther Burbank, Santa Rosa, Cal. = LBk
Brd	W. W. Barnard & Co., Chicago, Ill.
Bri	Wm. Brinker, Cleveland, Ohio.
Brk	Joseph Breck & Sons, Boston, Mass.
Brn	Alfred J. Brown Seed Co., Grand Rapids, Mich.
Brr	Fred P. Burr & Co., Middletown, Conn.
Brt	The W. E. Bartlett Co., Providence, R. I.
Bru	John A. Bruce & Co., Hamilton, Canada.
Brw	E. E. Burwell, New Haven, Conn.
Btl	F. Barteldes & Co., Lawrence, Kans.
Buc	H. W. Buckbee, Rockford, Ill.
Bui	Robert Buist Co., Philadelphia, Pa.
Bur	W. Atlee Burpee & Co., Philadelphia, Pa.
CA	Curry-Arrington Co., Rome, Ga.
Cam	L. Cameron, Jacksonville, Fla.
C&B	Clucas & Boddington Co., New York, N. Y.
CCo	Cole Seed Co., Buckner, Mo.
CE	Chesmore-Eastlake Mercantile Co., St. Joseph, Mo.
CF	Comstock, Ferre & Co., Wethersfield, Conn.
Chl	John Lewis Childs, Floral Park, N. Y.
Chm	M. Cushman & Co., Rochester, N. Y.
C&J	Cadwell & Jones, Hartford, Conn.
Cle	Cleveland Seed Co., Cape Vincent, N. Y.
Cok	A. T. Cook, Hyde Park, N. Y.
Col	Cole's Seed Store, Pella, Iowa.
Cox	Cox Seed Co., San Francisco, Cal.
Crg	Craig Seed Co., Memphis, Tenn.
Crs	Crosman Bros., Rochester, N. Y.
CSC	C. S. Clark, Wakeman, Ohio.
	The Everett B. Clark Co., Milford, Conn. = EBC
Cur	Currie Bros., Milwaukee, Wis.
D&C	The Dingee & Conard Co., West Grove, Pa.
DD	Dickmann-Dusard Seed Co., St. Louis, Mo.
Del	Delano Seed Co., Lee Park, Nebr.
D&H	Darch & Hunter, London, Ontario, Canada.
Dlw	W. E. Dallwig, Milwaukee, Wis.
Drm	Drumm Seed & Floral Co., Fort Worth, Tex.
Drr	Henry A. Dreer, Philadelphia, Pa.
Drw	Oliver H. Drew, Hibernia, N. Y.
Dun	R. B. Dunning & Co., Bangor, Me.

Eas	Eastman Seed Co., East Sumner, Me.
EBC	The Everett B. Clark Co., Milford, Conn.
Ebe	F. H. Ebeling, Syracuse, N. Y.
Ebr	W. M. Eber & Son, Quincy, Ill.
Eic	Eichling Seed & Nursery Co., New Orleans, La.
Elt	Wm. Elliott & Sons, New York, N. Y.
Emr	Thos. W. Emerson Co., Boston, Mass.
Evr	J. A. Everitt, Indianapolis, Ind.
Ewg	Wm. Ewing & Co., Montreal, Canada.
	Robert Evans Seed Co., Hamilton, Canada. = RE
Fax	M. B. Faxon, Boston, Mass.
Fer	D. M. Ferry & Co., Detroit, Mich.
Fld	Henry Field, Shenandoah, Iowa.
Fle	Fleming & Sons, Brandon, Manitoba, Canada.
Fmr	Farmer Seed Co., Faribault, Minn.
Fqr	R. & J. Farquhar & Co., Boston, Mass.
Frd	Ford Seed Co., Ravenna, Ohio.
Fst	H. G. Faust & Co., Philadelphia, Pa.
Gdn	Amzi Godden Co., Birmingham, Ala.
Ger	Germain Fruit Co., Los Angeles, Cal.
Gfg	The Griffing Bros. Co., Jacksonville, Fla.
Ggy	James J. H. Gregory & Son, Marblehead, Mass.
GH	The Goodwin-Harries Co., Chicago, Ill.
Gls	Heman Glass, Barnard's Rural Delivery, near Rochester, N. Y.
GN	The Great Northern Seed Co., Rockford, Ill.
Gng	Grainger Bros., Toronto, Canada.
Gra	Graham Bros., Ottawa, Canada.
Grn	W. H. Grenell, Pierrepont Manor, N. Y.
Grw	Griswold Seed Co., Lincoln, Nebr.
	Thomas Griswold & Co., S. Wethersfield, Conn. = TG
Gry	Thomas J. Grey & Co., Boston, Mass.
G&T	Griffith & Turner Co., Baltimore, Md.
Ham	Harry N. Hammond Seed Co., Bay City, Mich.
Haw	Budd D. Hawkins, Reading, Vt.
Hbt	Thos. W. Hobart, South Sioux Falls, S. Dak.
H&C	Hoermann & Cleary Seed Co., Terre Haute, Ind.
Hde	David Hardie Seed Co., Dallas, Tex.
Hen	Peter Henderson & Co., New York, N. Y.
Hlm	H. L. Holmes, Harrisburg, Pa.
Hly	The Holloway Seed & Grain Co., Dallas, Tex.
Hme	John Hume, Port Hope, Ontario, Canada.
Hns	Haines Seed Co., Denver, Colo.
Hnt	Hunt Seed Co., Lewistown, Pa.
Hop	Carl S. Hopkins, Brattleboro, Vt.
H&P	Huntington & Page, Indianapolis, Ind.
HP	The Henry Philipps Seed & Implement Co., Toledo, Ohio.
Hrm	H. T. Harmon & Co., Portland, Me.
Hrn	The Harnden Seed Co., Kansas City, Mo.
Hrs	Joseph Harris Co., Coldwater, N. Y.
Hrv	Harvey Seed Co., Buffalo, N. Y.
Hse	H. F. House & Co., Hiram, Ohio.
Hst	H. G. Hastings & Co., Atlanta, Ga.
Iml	Jno. D. Imlay, Zanesville, Ohio.
Iow	Iowa Seed Co., Des Moines, Iowa.

Jac	Jacobs Pharmacy, Atlanta, Ga.
JCM	J. Charles McCullough, Cincinnati, Ohio.
Jer	The George W. P. Jerrard Co., Caribou, Me.
Jes	Jessamine Gardens, Jessamine, Fla.
JL	Livingston's Seed Store, Des Moines, Iowa.
J&M	Johnson & Musser Seed Co., Los Angeles, Cal.
JMM	J. M. McCullough's Sons, Cincinnati, Ohio.
JMP	J. M. Philips' Sons, Mercersburg, Pa.
Jns	L. F. Jones Seed Co., Grand Rapids, Mich.
Joo	C. H. Joosten, New York, N. Y.
J&S	Johnson & Stokes, Philadelphia, Pa.
	Mark W. Johnson Seed Co., Atlanta, Ga. = MWJ
	R. H. Johnston, Victoria, B. C., Canada. = RHJ
Kei	Keith & Co., Winnipeg, Manitoba, Canada.
Kel	The Kelly Co., Cleveland, Ohio.
Ken	A. C. Kendel, Cleveland, Ohio.
K&F	Kennedy & Farnham, Carrollton, Mo.
Kg	T. J. King Co., Richmond, Va.
Koe	W. H. Koerner, Milwaukee, Wis.
Kos	Theo. Koss, Milwaukee, Wis.
Kra	I. N. Kramer & Son, Cedar Rapids, Iowa.
K&W	Kendall & Whitney, Portland, Me.
Lam	Buell Lamberson's Sons, Portland, Oreg.
Lan	D. Landreth & Sons, Philadelphia, Pa.
LB	Lilly, Bogardus & Co., Seattle, Wash.
LBk	Luther Burbank, Santa Rosa, Cal.
Lea	Leavings Bros. Seed Co., Paris, Ill.
Lnr	S. F. Leonard, Chicago, Ill.
Liv	The Livingston Seed Co., Columbus, Ohio.
	Livingston's Seed Store, Des Moines, Iowa. = JL.
Loh	The Lohrman Seed Co., Detroit, Mich.
Lon	W. B. Longstreth, Gratiot, Ohio.
Man	Mann & Co., Cape Vincent, N. Y.
	P. Mann & Co., Washington, D. C. = PM.
Mas	Geo. H. Mass, Woodstock, Vt.
Mau	Wm. Henry Maule, Philadelphia, Pa.
May	L. L. May & Co., St. Paul, Minn.
McK	A. E. McKenzie & Co., Brandon, Manitoba, Canada.
McM	McMillan's Seed Store, Atlanta, Ga.
	J. Charles McCullough, Cincinnati, Ohio. = JCM.
	J. M. McCullough's Sons, Cincinnati, Ohio. = JMM.
Mel	The Geo. H. Mellen Co., Springfield, Ohio.
Mgd	Mangelesdorf Bros. Co., Atchison, Kans.
Mhl	Henry F. Michell, Philadelphia, Pa.
Mic	Michael's Seed Store, Sioux City, Iowa.
Min	P. B. Mingle & Co., Philadelphia, Pa.
Mls	F. B. Mills, Rose Hill, N. Y.
Mnd	W. A. Manda, South Orange, N. J.
Mns	J. Manns Co., Baltimore, Md.
Mrs	C. C. Morse & Co., Santa Clara, Cal.
M&S	Moore & Simon, Philadelphia, Pa.
MV	Missouri Valley Seed Co., St. Joseph, Mo.
MWJ	Mark W. Johnson Seed Co., Atlanta, Ga.
Mzy	Muzzy Bros., Paterson, N. J.

Neb	The Nebraska Seed Co., Omaha, Nebr.
Nef	Lincoln I. Neff, Pittsburg, Pa.
NI	Northern Indiana Seed Co., Valparaiso, Ind.
NK	Northrup, King & Co., Minneapolis, Minn.
Nol	J. F. Noll & Co., Newark, N. J.
Old	L. L. Olds, Clinton, Wis.
OV	Ohio Valley Seed Co., Evansville, Ind.
Pac	Pacific Seed Co., Sacramento, Cal.
Pg	The Page Seed Co., Greene, N. Y.
	The Henry Philipps Seed & Implement Co., Toledo, Ohio.=HP.
	J. M. Philips' Sons, Mercersburg, Pa.=JMP.
Pir	The Pierce Seed Co., Pueblo, Colo.
Pks	J. M. Perkins, Winnipeg, Manitoba, Canada.
PM	P. Mann & Co., Washington, D. C.
Pne	Pine Tree State Seed Co., Bath, Me.
Pnt	Plant Seed Co., St. Louis, Mo.
Poo	Poole's Seed Store, Tacoma, Wash.
Por	Portland Seed Co., Portland, Oreg.
Pot	Walter A. Potter & Co., Providence, R. I.
Pri	George H. Price, Albany, N. Y.
Prn	F. R. Pierson Co., Tarrytown-on-Hudson, N. Y.
Ptt	Frank S. Platt, New Haven, Conn.
Pug	Puget Sound Nursery & Seed Co., Seattle, Wash.
Qkr	Quaker City Seed Co., Philadelphia, Pa.
Raw	W. W. Rawson & Co., Boston, Mass.
Rce	Jerome B. Rice, Cambridge, N. Y.
RE	Robert Evans Seed Co., Hamilton, Canada.
Ree	C. A. Reeser Co., Urbana, Ohio.
Ren	Wm. Rennie, Toronto, Canada.
RHJ	R. H. Johnston, Victoria, B. C., Canada.
Rim	Horace Rimby, Collegeville, Pa.
Rob	J. C. Robinson, Waterloo, Nebr.
Roc	Rockford Seed Co., Rockford, Ill.
Rog	Rogers Bros., Chaumont, N. Y.
Roh	Waldo Rohnert, Sargent, Cal.
RP	Rush Park Seed Co., Independence, Iowa.
Rs	Ross Bros., Worcester, Mass.
Rt	The A. I. Root Co., Medina, Ohio.
Rtk	J. R. Ratekin & Sons, Shenandoah, Iowa.
Sal	John A. Salzer, La Crosse, Wis.
SB	Steele, Briggs Seed Co., Toronto, Canada.
S&B	Schmidt & Botley, Springfield, Ohio.
SC	Schisler-Corneli Seed Co., St. Louis, Mo.
S&F	Schlegel & Fottler, Boston, Mass.
S&H	The Storrs & Harrison Co., Painesville, Ohio.
Shm	R. H. Shumway, Rockford, Ill.
Shw	Otto Schwill & Co., Memphis, Tenn.
Sie	Geo. L. Siegel, Erie, Pa.
Sim	J. A. Simmers, Toronto, Canada.
S&O	Shugart & Ouren Seed Co., Council Bluffs, Iowa.
Sox	Sioux City Seed & Nursery Co., Sioux City, Iowa.
Spf	Springfield Seed Co., Springfield, Mo.
Sqr	Jas. M. Squier & Son, Lindsay, Ontario, Canada.
S&R	Savage & Reid, Salem, Oreg.

Stk	J. Steckler Seed Co., New Orleans, La.
Stw	Stewart's Seed Store, Omaha, Nebr.
S&W	Stumpp & Walter Co., New York, N. Y.
Tat	George Tait & Sons, Norfolk, Va.
TB	Thompson Bros., Muscatine, Iowa.
T&B	Trumbull & Beebe, San Francisco, Cal.
Tem	L. Templin & Sons, Calla, Ohio.
Tex	Texas Seed & Floral Co., Dallas, Tex.
TG	Thomas Griswold & Co., S. Wethersfield, Conn.
Thb	William R. Thurber, Brooklyn, Conn.
Thm	T. H. Thompson Seed & Rice Milling Co., Houston, Tex.
Thr	J. M. Thorburn & Co., New York, N. Y.
Til	A. Tilton & Son, Cleveland, Ohio.
Tlh	Tillinghast Seed Co., La Plume, Pa.
	A. G. Tillinghast, Laconner, Wash. = AGT.
Tpk	Topeka Seed House, Topeka, Kans.
Trm	Trumbull & Co., Kansas City, Mo.
Vau	Vaughan's Seed Store, Chicago, Ill.
Vin	Sevin Vincent & Co., San Francisco, Cal.
Vk	James Vick's Sons, Rochester, N. Y.
Vl	The Vail Seed Co., Indianapolis, Ind.
Wat	George C. Watson, Philadelphia, Pa.
Wd	T. W. Wood & Sons, Richmond, Va.
W&D	Weeber & Don, New York, N. Y.
Wdr	S. D. Woodruff & Sons, Orange, Conn.
Wea	Geo. A. Weaver Co., Newport, R. I.
Web	Mel L. Webster, Independence, Iowa.
Wer	Wernich Seed Co., Milwaukee, Wis.
Wll	Oscar H. Will & Co., Bismarck, N. Dak.
Wlt	N. L. Willet Drug Co., Augusta, Ga.
WS	Wood, Stubbs & Co., Louisville, Ky.
Wyg	Adolphus Wysong, Lebanon, Ind.
Y&H	Young & Halstead, Troy, N. Y.
Yng	C. Young & Sons Co., St. Louis, Mo.

LIST OF VARIETIES.

Bell. Bak Blg Bgg Brb Brr Cle CF Ebe Emr Fqr Gra Gng G&T Grw TG Ham H&C J&S Kg Lnr Mgd Man PM Mns Mls NI Pac Pg Ptt Qkr S&F Sim Stk TB Web Wd WS.

Similar names. Large Bell, Improved Large Bell, Sweet Bell, Large Sweet Bell, Large Red Bell, Mammoth Bell, Golden Bell.

Seedsmen's synonyms. *Bull Nose*, Emr Fqr G&T J&S Lnr S&F, etc. *Sweet Mountain*, Ptt. *Improved Bull Nose*, Sim. *Large Squash*, Sim. *Large Bull Nose*, CF.

Bird's Eye. Bur Drr Eic Ger J&M Lan M&S Shw Stk S&W Thm.

Seedsmen's synonyms. *Creole*, Bur Drr J&M S&W Thm Vin, etc. *Small Chili*, Ger.

Black Mexican. Gra. For similar names see *Mexican.*

Black Nubian. Bgs Buc Cle Ewg Ren Rce Roc Shm Sim.

Bolgiano's Mammoth Ruby King. Entered as *Mammoth Ruby King.*

Bonnet. Lan.

Seedsmen's synonyms. *Squash*, Lan. *Tomato*, Lan.

Boston Squash. TG. For similar names see *Squash.*

Seedsmen's synonym. *Tomato*, TG.

Bull Nose. Alx Alr Bai Bak Brd Brt Bkt Bel Ber Blg Bow Bgg Brk Bdg Bgs Bri Brn Bru Bng Buc Bui Brb Bur C&J Cam CE Cle C&B Col Cox Crs Cur CA D&H DD Drr Drm Ebe Ebr Elt Emr RE Evr Fmr Fqr Fst Fax Fer Fle Frd Ger Gls Gdn GH Gra Gng Gn Gry G&T Grw TG Ham Hde Hrm Hrn Hrs Hrv Hst Hen Hbt H&C Hlm Hop Hse Hnt H&P Iml Iow Jac J&M J&S Jns K&F Kg Koe Kos Lam Lan Lea Lnr LB Liv JL Loh Mns Mgd Man PM Mns Mas Mau May JCM JMM McM Mel Mic Mhl Mls Min M&S Mzy Neb Nef Nol NI NK OV Pac Pg Pks HP Prn Pnt Ptt Poo Por Pot Pri Pug Qkr Raw Ree Roc Rt RP S&R SC S&F Shw S&O Shm Sie Sim Sox Spf Stk SB Stw S&H S&W Tat TB Thm Thb Til Tpk Trm T&B Vl Vau Vk Wea Web W&D Wll Wlt Wd WS Wyg Yng Y&H.

Similar names. Improved Bull Nose, Large Bull Nose, Sweet Bull Nose.

Seedsmen's synonyms. *Bell*, Blg Emr Fqr G&T J&S Lnr, etc. *Large Bell*, Bui Bur Drr Fer Hen Iow, etc. *Large Red Bell*, SB. *Large Squash*, Sim. *Large Sweet Bell*, Gls Mhl. *Mammoth Bell*, Cam Gdn Jac. *Spanish Monstrous*, Wlt. *Sweet Mountain*, Bru Hrn.

Burpee's Golden King, Burpee's Golden Upright, Burpee's Ruby King. Entered as *Golden King*, *Golden Upright*, and *Ruby King*.

Cardinal. Bgs Cle Crs RE Ewg Frd Gra Ggy Hen Ken Liv May M&S Mzy NK W&D.

Cayenne. Anb Ar Brd Btl Ber Bru Crg Crs CA Dlw Drm Ebr Ewg Fld Ger Gra Ggy G&T Hrs Hrv H&C Hnt H&P J&M Kei Lam Lan Lea Liv JL PM McK NI JMP Pir Prn Raw Ren Rt Rs Sal S&B Stw Thm W&D.

Similar names. Cayenne Pickling, Long Cayenne, Red Cayenne, Long Red Cayenne, Long Yellow Cayenne, Hammond's Long Red Cayenne, Small Cayenne, Small Red Cayenne, Little Red Cayenne, Large Red Cayenne.

Seedsmen's synonyms. *Long Red Cayenne*, Bur. *Chili*, JL.

Cayenne Pickling. Vau. For similar names see *Cayenne*.

Celestial. Alx Alr Ar Brt Btl Brk Bdg Bgs Buc Bui Bur Chl Cle Crs Cur CA D&H DD Drr Eas Ebe Ebr Elt RE Ewg Fqr Fst Frd Ger GH Gra Ggy Grw Ham Hrs Hly MWJ J&M J&S Kra Lan Lnr Liv Man May JCM JMM McM Mhl Mls MV M&S Nef Nol NK Ptt Pot Qkr Ren Rce Roc Sal S&O Shm Sim Spf Stk SB Stw Tem Thr Trm Vk Vin W&D.

Similar names. Childs' Celestial, Improved Celestial, Chinese Celestial.

Cheese. Min.

Cherry. Ar Brn RE Ewg Ger Gra Ggy Kei Ren Vau.

Similar names. Yellow Cherry, Red Cherry.

Childs' Celestial, Childs' Improved Celestial, Childs' Kaleidoscope. Entered as *Celestial* and *Kaleidoscope*.

Chili. Alx Bow Bru C&J Cam Cle C&B Cox DD Eas Ebe Elt RE Fqr Gdn Ggy Hde Hen Ken Lnr Man Mas McM Mzy Neb Pir Pnt Poo Por Pot S&R SC Stk SB S&W T&B W&D.

Similar names. Small Chili, Red Chili, Small Red Chili, Yellow Chili, Mammoth Chili, Large Mexican Chili, Mexican Chili.

Seedsmen's synonyms. *Cayenne*, JL. *Mexican*, DD.

C nese Celestial. Anb Evr Vl. For similar names see *Celestial*.

inese Giant. Bur D&H Drr Mau Thr. For similar names see *Procopp's Giant*.

ster. Pac.

Similar names. Japanese Cluster, Red Cluster, Japan Red Cluster.

mbus. Eic.

ral Gem. Drr Ebr RE Mhl Ree Sal S&F.

Similar name. Coral Gem Bouquet.

Coral Gem Bouquet. Buc Bur Col Cok D&H Evr Fqr Fst Frd Hbt Hse Iml Iow J&M Liv JL Mau M&S Pnt Raw Rce Roc Rs Vau Vk Wd WS.

Similar name. Coral Gem.

Seedsmen's synonym. *Red Cluster*, M&S.

County Fair. Hen Liv.

Similar name. Henderson's County Fair.

Cranberry. GH Mzy.

Similar name. Red Cranberry.

Creole. Bur Drr J&M M&S Shw S&W Thm.

Seedsmen's synonym. *Bird's Eye*, Bur Drr M&S Shw Thm Vin.

Dwarf Red Squash. Hlm. For similar names see *Squash.*

Early Dwarf Red Squash. Bur Frd GH Hbt Rce. For similar names see *Squash.*

Early Dwarf Squash. Raw. For similar names see *Squash.*

Elephant's Trunk. Bui Eic RE Hde J&S Koe Mau Pac Thr Vau.

Flat. Ggy.

Seedsmen's synonym. *Squash*, Ggy.

French Cayenne. Lan.

Giant Emperor. Ebr Mzy.

Giant of Valencia. Thr.

Giant Sweet Spanish. Kg. For similar names see *Sweet Spanish.*

Giant Yellow King Mango. Liv. For similar names see *Golden King.*

Golden Bell. Bui Hnt Lan HP Qkr Stw Wlt. For similar names see *Bell.*

Seedsmen's synonym. *Golden Dawn*, Bui HP Qkr Roc Wlt.

Golden Dawn. Alx Anb Ar Bai Brd Btl Ber Brk Bdg Bgs Brn Bru Buc Bui Bur Brr Cam CE Cle C&B Cok Crs Cur Del DD Drr Drw Ebe Ebr Eic Elt Emr ER Evr Ewg Fqr Fst Fer GH Gra Ggy Gry Grw TG Hns Hrs Hrv Hen Hly Hlm Hop Iml J&M J&S Kra Lam Lnr LB Liv Man Mas Mau May JCM JMM McM Mel Mic Mhl Mzy Neb Nol NI NK OV Pac HP JMP Pnt Por Pot Pri Qkr Raw Ree Roc RP Sal S&R S&F S&O Shm Spf Stk SB S&W Tat Tem Tex TB AGT Trm Vl Vau Vk Wea Web W&D Wer Wyg.

Similar names. Golden Dawn Mango, Sweet Golden Dawn, Mammoth Golden Dawn.

Seedsmen's synonyms. *Golden Bell*, Bui HP Ikr Wlt. *Golden Queen*, Buc Roc Vk.

Golden Dawn Mango. Entered as *Golden Dawn.*

Golden King. Bur D&C GH Rim.

Similar names. Burpee's Golden King, Giant Yellow King Mango.

Golden Prize. Hst.

Golden Queen. Brt Bkt Buc Bur CE Cle Del Drm Ebe Fld G&T Ham Hlm Liv Lon Mnd Mau May OV Ptt Roc Vk.

Similar names. Mammoth Golden Queen, Improved Golden Queen.

Seedsmen's synonym. *Golden Dawn*, Buc Roc Vk.

Golden Upright. Alr Bel Buc Bur DD Fst Frd GH Lnr Mls Rce Roc.

Similar name. Large Golden Upright.

Grossum. Bru Crs Hrv Sim Vk Vin.

Seedsmen's synonym. *Monstrous*, Bru Crs Hrv Sim Vk Vin.

Guthrey's Giant. SB. For similar names see *Procopp's Giant.*

Hammond's King of Reds, Hammond's Long Red Cayenne. Entered as *King of Reds* and *Long Red Cayenne.*

Henderson's County Fair. Entered as *County Fair.*

Hot Bull Nose. M&S. For similar names see *Bull Nose.*

Improved Bull Nose, Improved Celestial, Improved Golden Queen, Improved Large Bell, Improved Long Red, Improved Sweet Mountain, Improved Thick Long Red. Entered as *Bull Nose*, *Celestial*, etc.

Japanese Cluster. Ewg Gra W&D. For similar names see *Cluster.*

Japan Red Cluster. Drr Frd. For similar names see *Cluster.*

Seedsmen's synonym. *Red Cluster*, Frd.

Kaleidoscope. Buc Bur Chl Drw CE Gra Hst Hse Iow Liv JL NK Rce Roc.

Similar name. Childs' Kaleidoscope.

King of Reds. Ham.

Similar name. Hammond's King of Reds.

Large Bell. Alx Alr Anb Bai Brd Brt Bkt Bel Ber Bou Bow Brk Bdg Bgs Brn Bng Buc Bui Bur C&J CE Chl C&B Col Cox Crg Crs Cur CA D&H Del DD Drr Drm Dun Eas Ebr Elt RE Evr Ewg Fmr Fst Fax Fer Fle Frd Ger GH GN Ggy Gry Hde Hrm Hrs Hrv Hst Haw Hen Hbt Hlm Hop Hse H&P Iml Iow J&M Jns Kei K&W K&F Kos Kra Lam Lea LB Liv JL Loh Mas Mau May JCM JMM Mic MV Mzy Neb Nef Nol NK OV Pks HP JMP Prn Pne Pnt Ptt Poo Por Pot Pri Pug Raw Ree Ren Rce Roc Rs RP Sal S&R SC Shw S&O Shm Sie Sox Spf S&H S&W Tat Thm Thr Thb Til Tpk Trm T&B Vl Vau Vk Vin Wat Wea W&D Wll Wyg Yng Y&H.

For similar names see *Bell.*

Seedsmen's synonym. *Bull Nose*, Bui Drr Fer Hen Liv Raw, etc.

Large Bull Nose. Brr CF Drw MWJ. For similar names see *Bull Nose.*

Seedsmen's synonym. *Bell*, CF.

Large Golden Upright. NK. For similar names see *Golden Upright.*

Large Mexican Chili. J&M. For similar names see *Chili.*

Large Red. Ewg Gra Kei. For similar names see *Long Red.*

Large Red Bell. SB. For similar names see *Bell.*

Seedsmen's synonym. *Bull Nose*, SB.

Large Red Cayenne. Hrm Iml. For similar names see *Cayenne.*

Large Sweet. Bui G&T. For similar names see *Sweet.*

Seedsmen's synonym. *Sweet Mountain*, Bui.

Large Sweet Bell. Gls Hrv Mhl Min M&S Tex. For similar names see *Bell.*

Seedsmen's synonyms. *Bull Nose*, Mhl Gls. *Mountain*, Tex.

Large Sweet Mountain. Alx CF Drm Evr Ger Ggy Hrv Liv JL Old Pac Roc AGT Vl.

For similar names see *Sweet Mountain.*

Large Sweet Spanish. Bak Btl Bou Cam CA Dlw Drr Fst Gdn Gfg MWJ Lan Mel Mhl Pac Stw TB.

For similar names see *Sweet Spanish.*

Large Squash. Bow CF Crs RE Fer Hrm K&W LB MV NK Pri Rce Rs Sim Thr Til Y&H.

For similar names see *Squash.*

Seedsmen's synonyms. *Bell*, Sim. *Bull Nose*, Sim. *Tomato*, Bow Bdg CF Crs Rce.

Large Yellow. Kei. For similar names see *Long Yellow.*

Little Red Cayenne. Wd. For similar names see *Cayenne.*

Long Cayenne. Cox RE Gfg Hst RHJ Kos Lan Lnr Sim Vin Web Wyg Y&H.

For similar names see *Cayenne.*

Long Red. Btl Bkt Bel Bow Bgs Bri Bru D&H RE Ggy Lan Liv Ren Sal Sim.

Similar names. Improved Long Red, Thick Long Red, Improved Thick Long Red, Long Red Pointed, Large Red.

Seedsmen's synonym. *Santa Fe*, Ggy.

Long Red Cayenne. Alx Alr Anb Bai Bak Brt Bkt Blg Bow Brk Bdg Bgs Bri Brn Bng Buc Bui Bur Brr C&J Cam CE Cle C&B Col CF Crs Cur D&H DD Drr Ebe Eic Elt Emr Evr Fmr Fqr Fst Fax Fer Frd Gls Gdn GH Gng GN Gry Grw TG Hns Ham Hde Hrn Haw Hen Hly Hlm Hop Hse Jac MWJ J&S K&W Ken K&F Kra LB JL Loh Lon Mnd Mgd Man Mns

Mas Mau May JCM JMM McM Mhl Mls Min MV M&S Mzy Neb Nol NK OV Old Pac Pks HP Prn Pnt Ptt Pot Pri Ree Rce Roc RP SC S&F Shw S&O Sie Sox Spf Stk SB S&W Tat Tex TB Thr Thb Tpk Til Trm T&B Vl Vau Vk Wea W&D Wd Wdr WS Yng.

For similar names see *Cayenne.*

SEEDSMEN'S SYNONYM. *Cayenne,* Bur.

Long Red Pointed. Cox. For similar names see *Long Red.*

Long Yellow. Bgs Bru RE Gra H&P Iml Rce Sal S&O.

SIMILAR NAME. Large Yellow.

Long Yellow Cayenne. Buc Crs GH Mzy Roc. For similar names see *Cayenne.*

Mammoth. Brk Bgs Brb Bur C&B Crs Cur Elt Emr RE Evr Fqr Frd Gls Hen Iow K&W Kra Mzy Nol HP Rce S&O Sox Tem Thb Trm Vl Vk W&D Yng Y&H.

SIMILAR NAMES. Monstrous, Monstrous Mammoth, Sweet Mammoth, Sweet Orange Mammoth, Rose Mammoth.

SEEDSMEN'S SYNONYMS. *Sweet Mountain,* Bur Cur Elt Emr Hen Vk, etc. *Monstrous,* Evr Vl. *Sweet Spanish,* Trm.

Mammoth Bell. Cam Gdn Jac. For similar names see *Bell.*

SEEDSMEN'S SYNONYM. *Bull Nose,* Gdn Jac Cam.

Mammoth Chili. S&O. For similar names see *Chili.*

Mammoth Golden Dawn. McK Ren. For similar names see *Golden Dawn.*

Mammoth Golden Queen. Alr Bel Bru Col Frd Hse Iow J&S JL Mls M&S Pir Rce Shm Sim S&H Thr Wd WS.

For similar names see *Golden Queen.*

SEEDSMEN'S SYNONYM. *Mango,* Sim.

Mammoth Ruby King. Alr Bel Blg Drm J&M Liv JL Mns HP S&B Shm Thm.

For similar names see *Ruby King.*

Mammoth Ruby King Mango. Entered as *Mammoth Ruby King.*

Mammoth Sweet Mountain. Hse. For similar names see *Sweet Mountain.*

Mammoth Sweet Spanish. Wd WS. For similar names see *Sweet Spanish.*

Mango. Shm Sim.

SEEDSMEN'S SYNONYMS. *Mammoth Golden Queen,* Sim. *Sweet Mountain,* Shm.

Martinique. Eic.

Maule's Ruby King, Maule's Improved Ruby King. Entered as *Ruby King.*

Metcalf's Squash. Fqr. For similar name see *Squash.*

Mexican. DD Lan.

SIMILAR NAMES. Black Mexican, Mexican Chili, Large Mexican Chili.

SEEDSMEN'S SYNONYM. *Chili,* DD.

Mexican Chili. Ger Thm. For similar names see *Chili* and *Mexican.*

Mikado. Bur.

Monstrous. Bru Crs Evr Hrv NK Sim Stk SB Til Vl Vk Vin.

For similar names see *Mammoth.*

SEEDSMEN'S SYNONYMS. *Grossum,* Crs Hrv Vk Vin. *Mammoth,* Evr Sim Vl. *Sweet Spanish,* Stk.

Monstrous Mammoth. Anb Btl Hns. For similar names see *Mammoth.*

Monstrous Sweet Spanish. Ar Eic Rce Sie. For similar names see *Sweet Spanish.*

Moore & Simon's Scarlet Maddalon. Entered as *Scarlet Maddalon.*

Mountain. Tex. For similar names see *Sweet Mountain.*

SEEDSMEN'S SYNONYM. *Large Sweet Bell,* Tex.

Orange Wrinkled. Bur. For similar names see *Wrinkled.*

Oxheart. Hnt May Mzy NK Thr.

Pickling. Fqr S&F.

SEEDSMEN'S SYNONYM. *Squash,* Fqr S&F.

Procopp's Giant. Ar Btl Bel Ber Brk Bri Bru Bng Bui Brr Cle D&H Drr Elt RE Evr Ewg Fqr Fst Frd GH Gra Gng Ggy Gry Hde Hrs Hst J&M Liv Mau May McM Mls MV NK Pir Pnt Raw Ren Rce Sal SC S&F Shm Sim Sox Spf SB Thm Thr Vl Wer Wd WS.

Similar names. Guthrey's Giant, Chinese Giant, Salzer's Giant.

Red Cayenne. Del Iow Mhl Por S&R Stw S&H Tem AGT Wll.

For similar names see *Cayenne.*

Red Cherry. Alx Bai Brd Brt Blg Bow Brk Bdg Bri Bru Bui C&J CE Cle C&B Col Cox Crs DD Drr Ebe Eic Elt Emr Fqr Fer Gdn GH Gry G&T Hen Hly Hop H&P RHJ J&S K&W Lan Lnr LB Liv Mnd Mns Mhl MV Mzy Neb NK Pac HP Pnt Ptt Pot Pri Raw Rce SC S&F S&O Sox Stk Stw S&W Tat Tem Thr Vl Vk Wat W&D Wdr.

For similar names see *Cherry.*

Seedsmen's synonym. *Red Cluster*, Pac.

Red Chili. Bai Brt Btl Bkt Blg Brk Bdg Bri Brn Bng Buc Bur CE Col Crs Cur D&H Del Eic Emr Fst Fer Fle Gls GH Gng G&T Hns Hrm Hst H&C Hly H&P Iow Jac J&S Lam LB Liv Loh Mnd JCM M&S NK Pri Rce Rs Sal Shw Sie Thr Trm Vin Wer Wyg.

For similar names see *Chili.*

Red Cluster. Bdg Bgs Bur Chl Crs Ebe Eic RE Fst Frd Ger Gls Hde Hst Hen Hbt Hlm Iow Liv Mau May MV M&S NK Pac Pg Ptt Qkr Raw Rce Sal Sox Spf Stk S&W Thr Vau Vk Wll Wd WS Y&H.

For similar names see *Cluster.*

Seedmen's synonyms. *Japan Red Cluster*, Frd. *Coral Gem Bouquet*, M&S. *Red Cherry*, Pac.

Red Cranberry. Sal. For similar names see *Cranberry.*

Red Etna. Bur Ham Mls Rce.

Rose Mammoth. Ebe. For similar names see *Mammoth.*

Ruby King. Alx Anb Ar Bai Bak Brd Brt Btl Bkt Blg Bow Brk Bdg Bgs Br Brn Bru Bng Buc Bui Bur Brr Brw C&J Cam CE Chl Cle C&B Col CF Cok Cox Crs Cur CA Dlw D&H Del DD D&C Drr Drw Eas Ebe Ebr Eic Elt RE Evr Fmr Fqr Fst Fer Fld Frd Ger Gls Gdn GH Gra Gng GN Ggy Gry Gfg G&T Grw TG Hns Ham Hde Hrn Hrs Hrv Hst Haw Hen H&C Hly Hlm Hop Hse H&P Iml Iow Jac Jer MWJ RHJ J&S Jns Kg Koe Kos Lam Lan Lea Lnr LB Liv Loh Mnd Mgd Man PM Mas Mau May JCM JMM McK McM Mel Mic Mhl Mls MV M&S Mzy Neb Nef Nol NI NK OV Pac Pg JMP Pir Prn Pnt Ptt Poo Por Pot Pri Qkr Raw Ree Ren Rce Rim Roc Rs RP Sal S&R SC S&F Shw S&O Sie Sox Spf Stk SB Stw S&H S&W Tat Tem Tex TB Thr Thb Til Trm T&B Vl Vau Vk Vin Wea Web W&D Wer Wll Wd Wdr WS Wyg Yng Y&H.

Similar names. Burpee's Ruby King, Maule's Ruby King, Maule's Improved Ruby King, Mammoth Ruby King Mango, Mammoth Ruby King, Bolgiano's Mammoth Ruby King.

Salzer's Giant. Sal.

Santa Fe. Ggy.

Seedsmen's synonym. *Long Red*, Ggy.

Scarlet Maddalon. M&S.

Scarlet Wrinkled. Bur. For similar names see *Wrinkled.*

Small Cayenne. Lan HP Spf Stw. For similar names see *Cayenne.*

Small Chili. Drr Ger Grw Iml Mns May Mhl Ptt Tat Tex Vl Wea Wdr.

For similar names see *Chili.*

Seedsmen's synonym. *Bird's Eye*, Ger.

Small Red Cayenne. MWJ. For similar names see *Cayenne.*

Small Red Chili. Bak Bui MWJ Lan Roc Shm Sim Stw Til Vk.

For similar names see *Chili.*

Spanish Mammoth. Bru Fer Ken Rce. For similar names see *Sweet Spanish.*

SEEDSMEN'S SYNONYM. *Sweet Mountain,* Fer.

Spanish Monstrous. Bui Bur Fst Gng Ggy Hrn Lnr Mau JMM M&S Ree T&B Vau Wlt.

For similar names see *Sweet Spanish.*

SEEDSMEN'S SYNONYM. *Bull Nose,* Wlt.

Squash. Bai Brt Bgg Brk Bdg Bru Bui Brb C&J Cle Cox Emr Fqr Fax Ggy Gry Grw Lan Lnr Liv Min Mzy Pnt Ptt Pot Qkr S&F Thm T&B Vin.

SIMILAR NAMES. Large Squash, Boston Squash, Dwarf Red Squash, Early Dwarf Red Squash, Early Dwarf Squash.

SEEDSMEN'S SYNONYMS. *Tomato,* Bui Cle Cox Lan Lnr Liv, etc. *Pickling,* Fqr S&F. *Flat,* Ggy. *Bonnet,* Lan.

Sweet. Hly.

SIMILAR NAME. Large Sweet.

Sweet Bell. Mhl. For similar names see *Bell.*

Sweet Bull Nose. Hly. For similar names see *Bull Nose.*

Sweet Columbus. Eic.

Sweet Golden Dawn. MV Rce Sox Tat Thr Wlt.

For similar names see *Golden Dawn.*

Sweet Mammoth. Shw. For similar names see *Mammoth.*

Sweet Mountain. Alr Bai Brd Brt Bkt Ber Blg Bow Bgg Brk Bdg Bgs Bri Brn Bru Bng Buc Bui Brb Bur Brr Brw C&J Cle C&B Col Cox Crs Cur D&H Del DD Eas Ebe Ebr Elt Emr Fqr Fer Frd Gls GH Gra Gry Grw TG Hde Hrm Hrn Haw Hen H&C Hly Hlm Hop Hnt H&P Iml Iow Jns K&W Ken Kg Kra Lam Lea Lnr LB Loh Lon Mnd Mgd Mns Mau May JCM JMM Min MV Mzy Neb Nol NI NK OV Pg Pks HP JMP Pnt Ptt Pot Pri Raw Ree Rce Rs Sal SC S&F Shw S&O Shm Sox SB S&W Tem Thm Thr Thb AGT Til Vau Vk Vin Wea W&D Wdr Wyg Yng Y&H.

SIMILAR NAMES. Mountain, Mammoth Sweet Mountain, Large Sweet Mountain, Improved Sweet Mountain.

SEEDSMEN'S SYNONYMS. *Large Sweet,* Bui. *Bull Nose,* Bru Hrn. *Mammoth,* Bur Cur Elt Hen Iow Vk, etc. *Spanish Mammoth,* Fer. *Bell,* Ptt. *Sweet Spanish,* Bow H&P SB. *Mango,* Shm.

Sweet Orange Mammoth. Liv S&B. For similar names see *Mammoth* and *Sweet.*

Sweet Spanish. Bow Bdg Bng Cle C&B Cur CA Drm Eic Elt RE Evr Ewg GH Gra Hns H&P J&M Kei Lan Liv Mnd Mau Mzy NK Ren Rt Sal S&O Sim Stk SB S&W Tat Thm Thr Til Trm T&B W&D Wer.

SIMILAR NAMES. Spanish Monstrous, Spanish Mammoth, Large Sweet Spanish, Giant Sweet Spanish, Mammoth Sweet Spanish, Monstrous Sweet Spanish.

SEEDSMEN'S SYNONYMS. *Sweet Mountain,* Bow H&P SB. *Mammoth,* Trm. *Monstrous,* Stk.

Tabasco. Bur Col Drr Eic Jer Lan Mau Pnt Sal Stk Thr Wd.

Thick Long Red. Liv. For similar names see *Long Red.*

Tomato. Bai Bow Bgg Brk Bdg Bui Brb Cle CF Cox Crs TG Lan Lnr Liv Min Mzy Pnt Ptt Qkr Rce Thm T&B Vin.

SEEDSMEN'S SYNONYMS. *Squash,* Bui Cox Liv Ptt T&B Vin. *Bonnet,* Lan. *Large Squash,* Bdg Bow CF Crs Rce. *Boston Squash,* TG

Tom Thumb. Mau.

Wrinkled. Bgs Bur Liv Ren Vau.

SIMILAR NAMES. Yellow Wrinkled, Scarlet Wrinkled, Orange Wrinkled.

Yellow Cherry. Crs GH Pnt SC Thr. For similar names see *Cherry.*

Yellow Chili. Fer Hly NK Pg. For similar names see *Chili.*

Yellow Wrinkled. Bur. For similar names see *Wrinkled.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 7.

B. T. GALLOWAY, Chief of Bureau.

THE ALGERIAN DURUM WHEATS:

A CLASSIFIED LIST, WITH DESCRIPTIONS.

BY

CARL S. SCOFIELD,
EXPERT, BOTANICAL INVESTIGATIONS AND EXPERIMENTS.

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WASHINGTON:
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1902.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., November 8, 1901.

SIR: I have the honor to transmit herewith a paper by Mr. C. S. Scofield, entitled The Algerian Durum Wheats, and respectfully recommend that it be published as Bulletin No. 7 of this Bureau. The paper was prepared in connection with the Botanical Investigations and Experiments and was submitted by the Botanist.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

In the act making appropriations for the Department of Agriculture for the fiscal year 1902, under the head of "Botanical investigations and experiments," authority is given—

> To investigate the varieties of wheat and other cereals grown in the United States or suitable for introduction, in order to standardize the naming of varieties as a basis for the experimental work of the State experiment stations and as an assistance in commercial grading, and to investigate, in cooperation with the Bureau of Chemistry, the causes of deterioration of export grain, particularly in oceanic transit, and devise means of preventing losses from those causes.

The work thus authorized falls under two heads, a purely botanical investigation of the varieties of cereals and a general investigation of the methods of grading and shipping export grain. Both lines of inquiry have been placed in charge of Mr. Carl S. Scofield.

From October, 1900, to July, 1901, Mr. Scofield was in Algeria and western Europe, engaged in work on cereals, and devoted about three months to the study and introduction of the Algerian durum wheats, a work suggested and supervised by Mr. W. T. Swingle of the Department of Agriculture. These wheats form an important export from Algeria to Europe for use in the manufacture of macaroni, and their recent introduction into American agriculture by this Department makes it important that the agricultural experiment stations as well as private experimenters and investigators, including progressive manufacturers and farmers, should have a precise understanding of the characteristics of the important varieties. If it shall later be found that a particular variety of Algerian durum wheat—for example, Pelissier—is notably successful in this country because of its productiveness or the superior adaptation of its gluten to macaroni making, that variety will then be known everywhere by that one name and experimenters and farmers will not be subjected to the great waste of time and money that follows when the same name is loosely applied to two or three or half a dozen varieties that have very different qualities.

For the general plan of this publication Mr. Scofield desires to acknowledge his indebtedness to the "Catalogue Méthodique et Synonymique des Froments," by M. Henry L. de Vilmorin, with additional thanks to M. Philippe de Vilmorin for many kind suggestions and the opportunity of visiting the large collection of wheats at Verrières.

The work for the publication was done chiefly in the laboratories of Dr. L. Trabut, "Chef des Services Botaniques de l'Algérie," who very kindly not only gave Mr. Scofield the free use of his laboratories, photographic apparatus, and herbarium, including one of the best existing collections of durum wheats with his notes thereon, but also gave much attention and personal interest to the work, for which the author feels the deepest gratitude, and without which the work could scarcely have been accomplished.

FREDERICK V. COVILLE.
Botanist.

OFFICE OF THE BOTANIST,
Washington, D. C., November 6, 1901

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THE ALGERIAN DURUM WHEATS: A CLASSIFIED LIST WITH DESCRIPTIONS.

INTRODUCTION.

Owing to the great variability of the wheat plant, due in part to its high development and the artificial conditions of its culture, its varieties are extremely difficult to classify. In fact, any attempt to list and describe all existing types of wheat would be an endless task; for almost all imaginable types can now be found or are liable to be produced. Of all the existing forms, comparatively few are of sufficient economic value to find a place in general culture, so that a practical systematic account of varieties for the use of the plant breeder and variety tester can be made by describing as accurately as possible the forms now prominent, leaving place for new ones that may appear, and claiming to be final only in the insistence that one name shall be connected solely with one variety, thus avoiding confusion and misunderstanding in the literature of the subject and in commercial dealings.

OBJECT OF A DESCRIPTIVE CLASSIFICATION OF WHEAT VARIETIES.

An accurate and detailed description of wheat varieties, with a classification based thereon, may be so used as to have a harmful as well as a beneficial result. The important point in a variety is that it yield the largest possible amount of grain of the best quality for the purpose desired under given conditions. The ability to do this is not always indicated by the morphological characteristics of the plant. Plants growing together under the same conditions do not all vary alike. Certain ones find peculiar conditions more congenial and develop more vigorously, so that after a few generations the plants which succeed best naturally replace the others, unless artificial selection interferes. A variety produced in one locality might be made up of plants having certain well-marked similar points. Under different conditions some of these plants might change in a certain respect, and others remain nearly constant with regard to this particular point. Some of the plants which change might find the new conditions better adapted to their growth and gradually replace the others which might be considered to be of the true type. Were artificial selection to be used here in such a way as to discriminate against the better-yielding plants, for example, it would be used with harmful effect. In other words, a minute botanical description unless used wisely is quite as likely to be harmful as useful. The possibility of this is, however, small in comparison with the possibility of usefulness in an accurate description and classification of varieties of wheat. The confusion and misunderstanding resulting from a lack of accurate knowledge of the varieties for which names are used are very great. There can be but little object in giving a variety a name, unless a definite record or description is available that will make the name mean something. It is at present not an uncommon thing to find two or more names applied to a single variety of wheat, or to find a single name applied to several distinct varieties. A simple and accurate description would do much toward preventing such a condition of affairs.

In many cases where large numbers of closely allied varieties are on trial under similar conditions, there are few clean-cut morphological distinctions that can, with our present limited knowledge of the plants, be stated. The only difference noticeable often is in yielding capacity. This, of course, must be observed and put on record. It is not to be expected that a method of description, however accurate, can ever replace the pedigree method of recording varieties; but it is hoped that such a description may supplement the records and help to simplify them and to avoid errors.

Since a change in conditions of soil and climate causes variation in botanical characteristics, as well as in the yield and quality of the grain of the wheat plant, it is impossible to correctly describe varieties gathered from widely different sources after they have been grown for several generations in one place under nearly the same conditions. The aim should rather be to describe a variety as growing under the conditions where it reaches the best development, when it may also be possible to add to the description of its botanical form certain sharply defined chemical characteristics of the grain. It now seems possible to outline methods of description that will meet this purpose, and this will render unnecessary the collection of varieties from various localities for comparison side by side and the study of the variations induced by the incident change of conditions.

The laws of variation in wheat due to climate, food supply, and hybridization are not yet well enough known to permit the use of a system of classification which is not more or less arbitrary. Natural relations and affinities are often hard to trace, and it seems better to start with some practical system, however arbitrary, and then rearrange the classification as rapidly as the data for doing so are obtained.

BASIS OF PRESENT DESCRIPTIONS AND CLASSIFICATION.

The varieties of wheat belonging to the botanical species *Triticum durum* make up the class known in the United States as "goose" or "rice" wheats. These names are applied on account of the horny texture of the kernel, which shows little or none of the starchy, white appearance in cross section that is found in the grain of varieties of *Triticum aestivum*, a species more commonly known as *Triticum vulgare*, to which most of our commonly cultivated wheats belong. The durum varieties as a class differ further from the vulgare varieties in that they are, so far as known, all bearded, and the beards are particularly strong and stiff. Also, the midrib or keel of the outer glumes is always prominent in the durum varieties and extends the entire length of the glume.

The present classification is based on differences observable in the head and grain. There are doubtless valuable characters to be made out from a study of the leaf and stem; and the time of ripening and general color of the plant are also points of great importance. As these grounds of distinction, however, were not available in case of some of the varieties here considered, they are not used at all in the present work.

STRUCTURE OF THE WHEAT HEAD.

The flowering and fruiting cluster at the summit of the stem of a wheat plant is called indifferently the "head" or "spike." The portion of stem running through the spike, on which the flowers or kernels are borne, is called the "rachis." The rachis is divided by a number of joints or "nodes," and at these nodes on alternate sides of the rachis are attached the "spikelets," i. e., the several small secondary spikes which, together with the rachis, make up the spike proper. The short branch running through each spikelet is known as the "rachilla." Inserted upon the rachilla are several concave scales which are called the "glumes." The two lowest and outermost of these contain no flowers or kernels, and are designated as the "flowerless glumes." Above these, arranged alternately, are borne the flowers—rarely less than two or more than five. Each flower, and as it matures, each grain, is subtended by a single glume, known as the "flowering glume." Each flowering glume has a longitudinal nerve, which at the summit extends into a prominent "awn" or "beard." On the inner or creased side of the grain or "berry," filling it very closely and more or less hidden from view by the flowering glume, is borne the "palea" or "palet," a thin scale with two nerves. The flowerless and flowering glumes and the palets are spoken of collectively as the "chaff."

The outer or flowerless glumes in all varieties of *Triticum durum* have a prominent midrib or "keel" extending from the base to the tip, terminating in a "beak" of varying length and thickness. The rachis often bears rather long, stiff hairs about the base of the rachilla, but these should not be confused with the short, soft hairs often borne on the surface of the outer glumes. It is the latter that are referred to when the term "hairy chaff" is used.

The spike in varieties of *Triticum durum* is often symmetrical to one longitudinal plane only, i. e., to a plane separating the rows of spikelets. This single longitudinal symmetry is shown in Plate I, where three spikes of the same variety (Pelissier) are shown in different positions. It is readily seen that in *a* the bases of the spikelets overlap much more than in *c*, which is the opposite side of a similar spike. For convenience, the view shown in *c* is called the front view, that in *a* the back view, and that in *b* the side view. When the condition shown in Plate I, *c* is slightly more pronounced, the rachis is readily visible in the front view, as, for instance, in Plate XVII, figure 1. This monosymmetry, which is due to the bases of the spikelets overlapping more on one side than on the other, is often attended by a curvature of the spike, the side seen in the front view being the concave one.

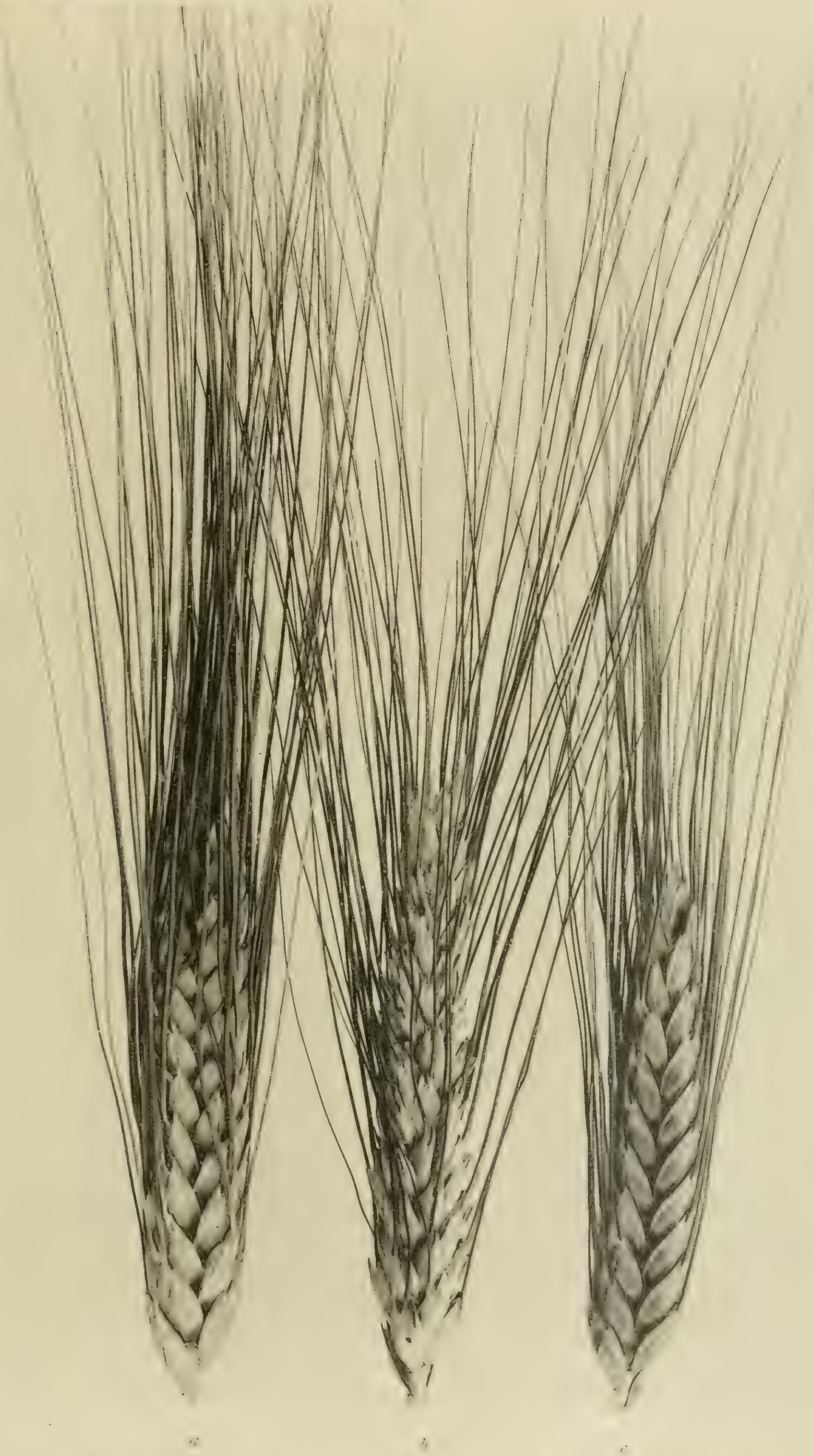
GRAIN CHARACTERS.

The grain of wheat by its differences in shape, size, and color offers points of distinction that are very clear, and these used in connection with the characters furnished by the spike and spikelet afford ample means for definite description and reasonably extended classification. The grain of durum wheat varies in color from whitish amber to dark red. It may be clear, i. e., almost translucent, or dull, i. e., quite opaque. It also varies widely in its general size and shape. (See Plate III, fig. 2.)

There are decided differences in both the quality and the quantity of the nitrogenous material contained in the grain, and these differences are reasonably constant within the variety under given conditions. They are approximately stated when the color and the quality, as determined by the general appearance, are given. It is probable that in time chemical methods will be devised by which it will be possible to express quality of wheat in accurate figures, "quality" meaning quantity of nitrogenous material and relative amount of its important constituents. The quality of a variety stated in these terms would determine for what use it is best fitted and its approximate value for that use.

RELATIVE VALUE OF CHARACTERS.

The general appearance of the spike or of the grain of a wheat variety is one of the things that fixes it in mind. Accurate description is only the analysis of the general appearance to its simplest details and a statement of these details. Varieties may then be separated into groups on the basis of this description, these groups again split, and so on until the limit, which is the single variety, is reached. This separation is made arbitrarily, using what appear to be the most important and constant details first. There is often some uncertainty or difference of opinion as to which are the most important and con-



THREE SPIKES OF DURUM WHEAT, VARIETY PELISSIER, IN DIFFERENT POSITIONS.

HELIOTYPE CO., BOSTON.

stant characteristics. For instance, it is generally assumed that the distinction between a smooth and a hairy chaff is reasonably important and constant, but in the case of the variety "Pelissier" it is difficult to say to which class it really belongs. It is possible that this is a case of two varieties approaching similarity in all points but that of pubescence. It is more probable, however, that it is a case of extreme variability in this particular. Other equally ambiguous cases arise, but it is believed that sufficient accuracy of description and reproduction have been secured to be of substantial assistance to those who deal with these varieties in variety testing or improvement, or in a commercial way.

GLOSSARY OF TERMS USED.

(For illustrations see Pls. II and III.)

AURICULATE.—Eared. Applied to the summit of the flowerless glumes when the wings are extended upwardly in earlike form. See Shoulder.

BEAK.—The projecting tip of the keel of the flowerless glumes, which, though sometimes prominent, never becomes long enough to be called a beard.

BEARD, BEARDED.—The beard consists of the long, stiff awns borne at the tips of the flowering glumes.

BREADTH.—As applied to the head or spike, the approximate measurement of the width of the head, exclusive of beards, taken across both rows of spikelets in the view in which the heads are shown in the cuts.

BRUSH.—The hair found on the upper end of the grain.

CHAFF.—Collective term for the flowerless and flowering glumes and the palets.

DURUM.—Used to indicate the varieties of wheat belonging to the species *Triticum durum*. The same term may be used in commerce to distinguish these wheats, which are best for the manufacture of macaroni, from the "vulgare" wheats, which are best for breadmaking purposes.

FLAT.—A spike is said to be flat when its breadth is considerably greater than the width of a single spikelet, i. e., when the breadth of the spike conspicuously exceeds its depth.

GLUME.—One of the concave scales of the spikelet. The empty pair at the base of the spikelet are the "flowerless glumes." The remainder, containing flowers or grains, are called the "flowering glumes."

HAIR, HAIRY.—Used with reference to the pubescence which is sometimes present on the glumes, chiefly on the outer or flowerless ones. Terms not to be confused with beard and bearded, and as here used not applied to the hairy growth often found on the rachis at the base of the spikelet.

HEAD.—Same as spike.

KEEL.—The prominent rib extending from the base to the tip of the flowering glumes on the back.

LENGTH.—As applied to the head or spike, the measurement from the lowest node to the tip of the glume of the terminal spikelet.

PALEA, PALET.—The thin, two-nerved scale on the inner or creased side of the berry. Seldom referred to in the descriptions.

SHOULDER.—As applied to the outer glume, denoting the wing on each side of the beak, which often forms an earlike (auriculate) projection. (See Plate II, fig. 2.) Descriptions using this term can be only relative or comparative, because of the variation in the same head, the shoulder being narrower and the auriculation less pronounced in the spikelets near the base than in those toward the apex of the spike; but this difference is reasonably constant within the variety.

SMOOTH.—As applied to the glumes, this means simply not hairy.

SPIKE.—The flowering or fruiting cluster at the summit of the stem.

SPIKELET.—One of the short branches of the spike with its glumes and palets and flowers or kernels.

VULGARE.—Used to designate all varieties of wheat belonging to the species best known as *Triticum vulgare*, but according to the revised nomenclature properly called *Triticum aestivum*.

GENERAL CHARACTER OF THE DURUM WHEATS.

The present work deals with some of the more important varieties of *Triticum durum* now grown in a general or experimental way in Algeria, North Africa.

The soil and climate of the tillable portion of Africa north of the Sahara Desert are favorable to the production of durum wheats, which, though not containing as large a quantity of nitrogenous material as the similar wheats of Southern Russia, still furnish a quality of this material so well adapted to the manufacture of macaroni and similar paste foods that the product in quality rather excels that derived from the Russian varieties. It may be well to say here that commercially the chief use of the durum wheats is for the manufacture of paste foods. For this purpose it is necessary to have a gluten decidedly different in character from that desired for breadmaking purposes. Bread is, however, made extensively from flour of durum wheat in countries where this is almost the only wheat grown.

The bread thus made is usually darker in color and heavier and tougher in texture than that made from flour of vulgare wheats, but has a very pleasant flavor and is considered highly nutritious, since durum wheats as a rule contain more proteid matter than vulgare wheats.

Certain peculiar variational tendencies are found in common among the varieties of North African durums. In case of varieties having colored chaff and beards the color becomes more pronounced as they are grown where the sunlight is more intense and the relative humidity of the atmosphere is less, and in general the quality of the grain improves as the intensity of the sunlight increases and the relative humidity of the atmosphere decreases. There is considerable variation as to rust resistance among the varieties of durum wheat, but they will probably average more rust-resistant than the varieties of *Triticum aestivum*. This is due in part to their vigorous growth and to the fact that they find their highest development in climatic conditions unfavorable to the growth of rust.

They are, however, somewhat subject to attacks of smut (*Ustilago tritici*); not more so probably than the vulgare wheats, but enough so that a fungicide treatment is usually given to the seed wheat in Algeria, particularly in the province of Constantine.

The varieties of durums so far grown in the United States have proved better yielders under semiarid conditions than the vulgare wheats. Algerian varieties of durum wheats are always grown with autumn planting, but it is probable that most of these varieties will succeed with spring sowing in the northern portion of the Mississippi Valley. The yield and rust resistance will be determined largely by the time of ripening of the different varieties.

It is to be hoped, since durum wheat is likely to be more generally distributed and more widely grown in the near future in the United States, that the men who grade and handle grain may learn to know it readily and that they will give it a distinct place in the general system of grades, so that there will be no necessity for the grower to mix it with vulgare wheat in order to sell it, thus greatly lowering the value of both sorts, since they are difficult to separate and are of much less value when mixed.

The places in the United States where durum wheats are likely to grow best are the somewhat dry yet tillable portion of the Great Plains west of the Mississippi River and the Red River of the North and the irrigated region of the Southwest.

The chief use of this wheat will be for the manufacture of macaroni and similar paste foods, for it is the only wheat with which a first-grade article of this class can be made. For the manufacture of breakfast foods its high proteid content and its pleasant flavor are likely to recommend it, and it will find a limited use in affording a cheap but nutritious bread in localities where its increased yield will make it cheaper than vulgare wheat.

EXPLANATION OF PLATE II.

Figure 1 represents a spikelet of the variety Beliouni magnified six times. This shows the smooth chaff with the cluster of hairs on the portion of the rachis just below the spikelet. The long, slender beak is shown extending well beyond the tip of the flowering glume. The shoulder of the outer glume is fairly prominent in this view and is sharply auriculate. The prominent keel of the outer glume can be seen only near the base and tip, the middle being out of view.

Figure 2 shows a spikelet of Mohamed ben Bachir with hairy chaff, magnified as above. This spikelet is much narrower than the preceding one, containing but three grains. The beak is very short, not reaching the tip of the flowering glume. The shoulder of the outer glume is very broadly auriculate, and the deep indentation separating the beak and auricle is shown in the glume at the extreme left.

PLATE II.

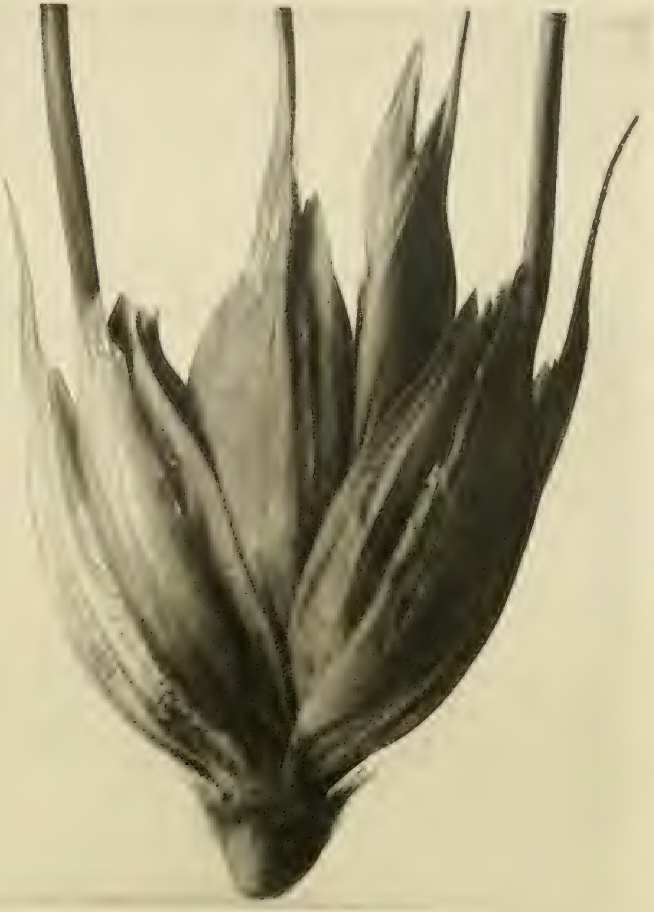


FIG. 1.

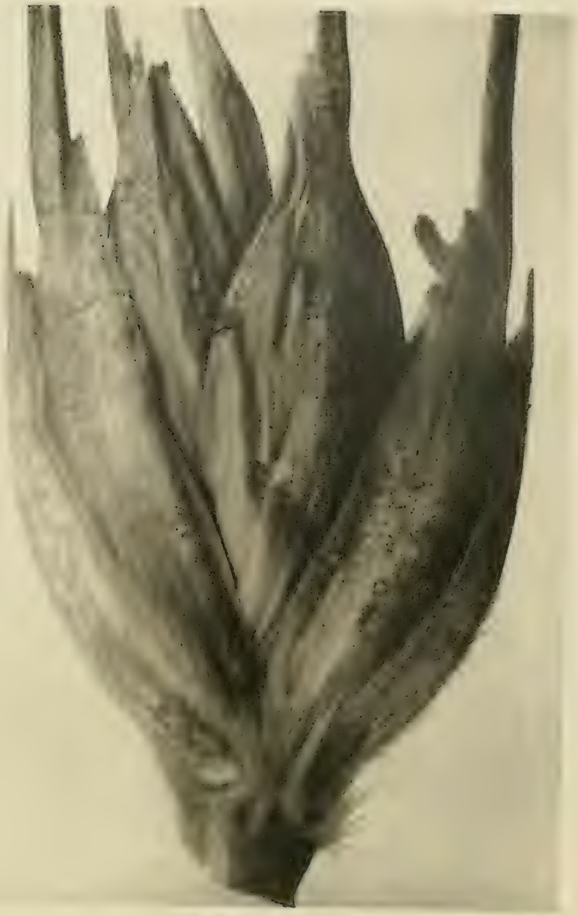


FIG. 2.

SPIKELETS OF DURUM WHEATS: FIG 1, BELIOUNI; FIG. 2, MOHAMED BEN BACHIR.

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EXPLANATION OF PLATE III.

Figure 1 shows the two flowering glumes with the mature grain, subtended by the outer flowerless glume, as seen in the variety Moroccain, magnified six times. The chaff is smooth; the beak of the keel is of medium length, but does not pass the tip of the flowering glume. The shoulder of the outer glume is narrow and shortly but sharply auriculate. Of the chaff the inner scale (palea) fits closely about the grain, and with it is held snugly within the flowering glume when in normal position. Only the flowering glumes ever bear a long awn or beard, and this in the cut is broken off.

Figure 2 shows two varieties of grain magnified six times. The longer grains are those of Nab el Bel, which are described as being long and slender, and the others are from Meskiana and are short and broad. The side view of the longer grain shows a curvature in the outline. This is sometimes very pronounced, and from this shape of the grain the variety gets some of its names.

The hair visible on the upper end of the grain is "the brush." It is usually less abundant in the durum than in the vulgare wheats.

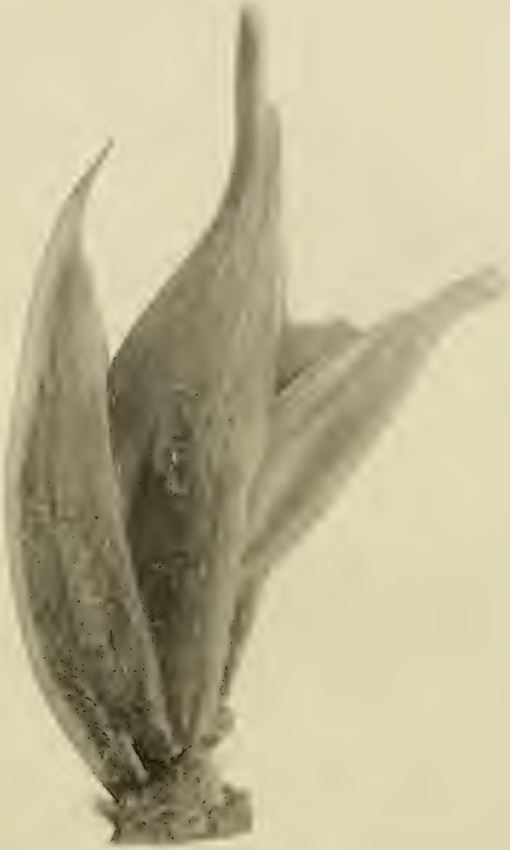

FIG. 1.

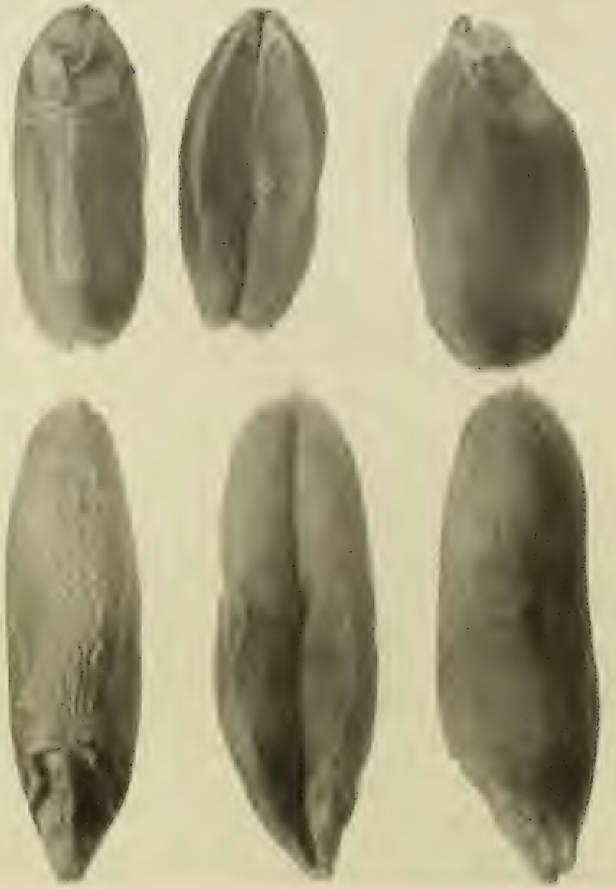

FIG. 2.

DURUM WHEATS: FIG. 1, PART OF SPIKELET OF MOROCCAIN; FIG. 2, GRAINS OF NAB EL BEL AND MESKIANA.

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DESCRIPTION OF VARIETIES WITH KEY.

This key is intended to serve as a guide in placing a variety near where it belongs. It is constructed on a dichotomous system, which separates the subject matter into classes on the basis of sharp differences in the particular aspect chosen as the ground of comparison. The figure on the right in each case refers to the same figure on the left of the page where the next division is made.

1	Spikes straight, or nearly so; rachis concealed by the overlapping bases of the spikelets; chaff either smooth or hairy; grain either red or amber	2
	Spike more or less curved; rachis nearly or quite exposed on the concave side; grain amber; chaff white, or nearly so	27
2	Chaff smooth, i. e., not pubescent	3
	Chaff more or less hairy	16
3	Grain amber	4
	Grain red	15
4	Chaff white, or nearly so	5
	Chaff strongly colored	11
5	Beards white or straw-colored	6
	Beards nearly or quite black	*Pelissier.*
6	Beak of keel two to four times as long as broad	7
	Beak of keel five or six times as long as broad	10
7	Beak distinctly passing tip of flowering glume	8
	Beak scarcely reaching tip of flowering glume	9
8	Spikes about 1.2 cm. broad; spikelets bearing three or four grains	*Aicha el Beida.*
	Spikes about 1 cm. broad; spikelets bearing two or three grains	*Poulot.*
9	Spike about the same size from base to tip; shoulder of outer glume very slightly auriculate	*Beloturka.*
	Spike tapering from base to tip; shoulder of outer glume sharply auriculate	*Courtellement.*
10	Shoulder of outer glume broad; not sharply auriculate; grain short and broad	*Xeres.*
	Shoulder of outer glume narrow; sharply auriculate; grain long and slender	*Moroccain.*
11	Chaff red; beards brown or black	12
	Chaff and beards black	14
12	Spike tapering from base to top; beards somewhat deciduous	*Medeah.*
	Spike about the same size from base to tip; beards vigorous and well retained	13
13	Spikes about 1.2 cm. broad; spikelets bearing three or four grains; shoulder of outer glume broad, sharply auriculate	*Beliouni.*
	Spikes about 1 cm. broad; spikelets bearing usually two grains; shoulder of outer glume very narrow, slightly auriculate	*Paros.*
14	Spike about 8 cm. long; grain clear, dark amber	*Kahla.*
	Spike about 6 cm. long; grain dull, whitish amber	*Caïd de Siouf.*
15	Spike about 0.8 cm. broad; beak of keel five to six times as long as broad; shoulder of outer glume narrow, distinctly auriculate	*Trimenia.*
	Spike about 1.1 cm. broad; beak of keel three or four times as long as broad; shoulder of outer glume broad, not sharply auriculate	*Hached.*
16	Grain red	17
	Grain amber	19
17	Spike somewhat club-shaped	*Tesdouni.*
	Spike tapering toward the tip, or at least not club-shaped	18

18	Spike distinctly flattened; grain long and slender	*El Aoudja.*
	Spike not perceptibly flattened; grain short and broad	*Boghar.*
19	Chaff white	20
	Chaff red or slightly brown	24
20	Beards black	*Pelissier.*
	Beard white or straw-colored	21
21	Spike distinctly flattened	22
	Spike barely or not at all flattened	23
22	Spike about 1.5 cm. broad; shoulder of outer glume sharply auriculate; grain long and slender	*Nab el Bel.*
	Spike about 1.1 cm. broad; shoulder of outer glume slightly or not at all auriculate; grain short and broad	*Meskiana.*
23	Beak of keel blunt, about as broad as long	*M'Saken.*
	Beak of keel sharp, two or three times as long as broad	*Medeba.*
24	Beards straw-colored or red	25
	Beards black	26
25	Beak of keel passing tip of flowering glume; shoulder of outer glume narrow, slightly auriculate	*El Hamra.*
	Beak of keel hardly reaching tip of flowering glume; shoulder of outer glume broad, sharply auriculate	*Azizi.*
26	Shoulder of outer glume reduced to a slender tooth; chaff often streaked with black	*Maroc.*
	Shoulder of outer glume broad, deeply auriculate; chaff not streaked with black	*Makouwi.*
27	Chaff smooth; beards sparse and weak, glumes often more than 2 cm. long	*El Safra.*
	Chaff more or less hairy; beards strong; glumes often long but never reaching 2 cm. in length	28
28	Beards nearly or quite black	*Caïd Eleuze.*
	Beards straw-colored	29
29	Spikes tapering decidedly in the upper half	30
	Spike not tapering perceptibly except at extreme tip	31
30	Spike 5 to 7 cm. long; grain dull amber	*Zedouni.*
	Spike 8 to 10 cm. long; grain very light clear amber	*Ouchda.*
31	Spike about 2.2 cm. broad	*Aures.*
	Spike about 1.5 cm. broad	*Adjini.*

AICHA EL BEIDA.

Plate IV, Fig. 1.

Spike straight or nearly so; chaff smooth, white; grain clear amber; beards white or straw-colored; beak of keel two to four times as long as broad, distinctly passing the flowering glume; spikes about 1.2 cm. broad; spikelets bearing three or four grains.

This variety is grown to some extent on the high plateau of Constantine, near Meskiana, but it has not proved vigorous enough to hold a very important place in general culture there, where popular sentiment demands a wheat with a shorter, more compact head. The derivation of the name is: "Aicha," a term of endearment applied to a woman, and "el Beida," which means "the white."

COURTELLEMENT.

Plate IV, Fig. 2.

Spike straight or nearly so; chaff smooth, white; grain amber; beards white or straw-colored; beak of keel two to four times as long as broad, scarcely reaching the tip of the flowering glume; spike tapering from base to tip; shoulder of outer glume sharply auriculate.

This variety is from seed sent to Algeria from Syria by Mr. Courtellement, a traveler, from whom it takes its name. It is not widely known nor generally grown in Algeria, but deserves attention from the fact that the beards are somewhat deciduous, readily breaking off as the plant reaches maturity.

PLATE IV.

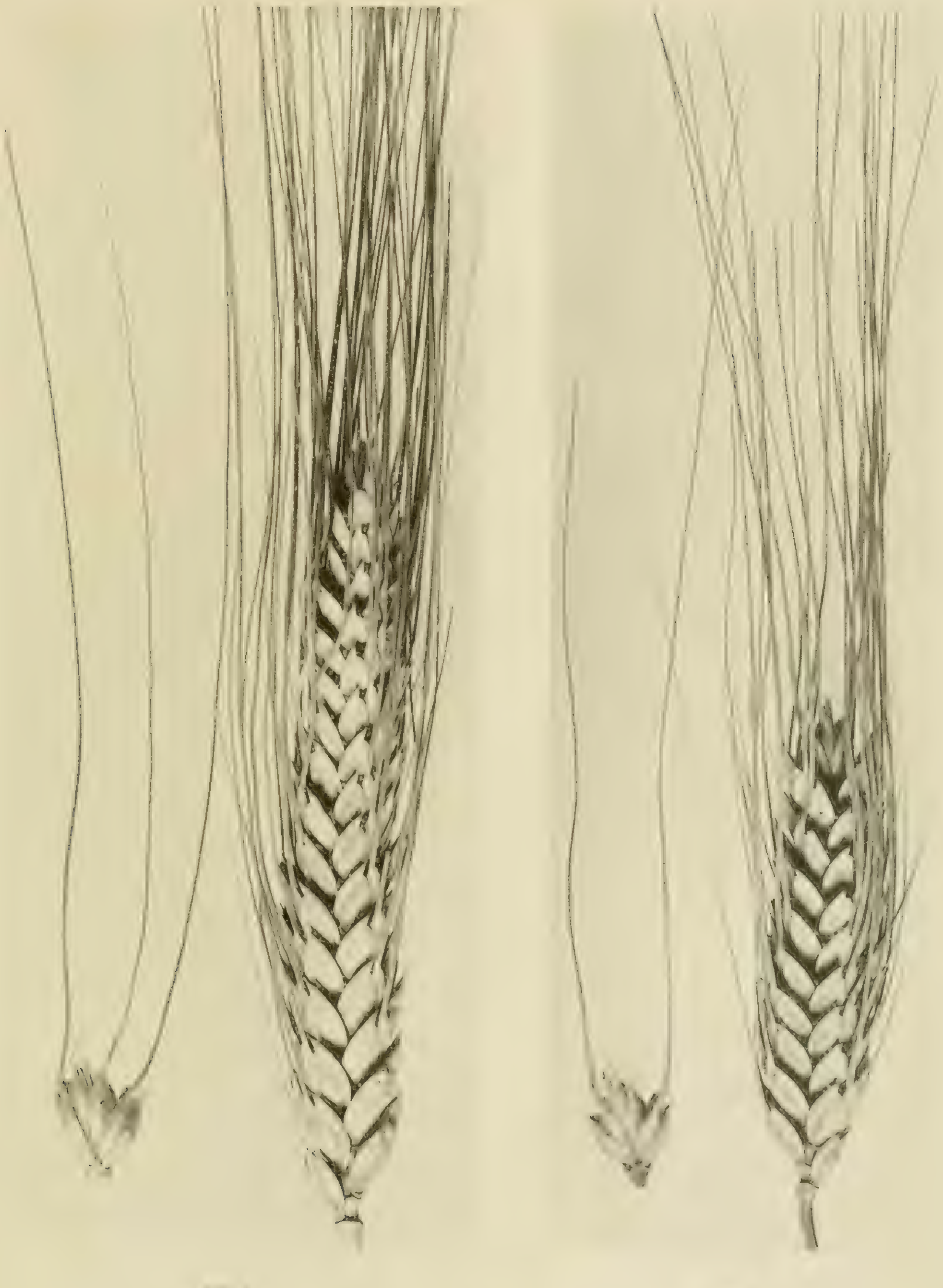

FIG. 1.

FIG. 2.

DURUM WHEATS: FIG. 1, AICHA EL BEIDA; FIG. 2, COURTELLEMENT.

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BELOTURKA. Synonym: Kubanka.

PLATE V, FIG. 1.

Spike straight or nearly so; chaff smooth, white, or nearly so; grain amber; beards white or straw-colored; beak of keel two to four times as long as broad, scarcely reaching the tip of the flowering glume; spike about the same size from base to tip; shoulder of outer glume very slightly auriculate.

This variety is of Russian origin, as the name indicates. It is grown rather extensively in Algeria, but under a great variety of names. It yields fairly well, but the grain is somewhat inferior in quality to that of the best Algerian wheats, and very much inferior to what it is when grown in Russia. It is probably adapted to land much richer in humus than the average Algerian soil.

XERES. Synonym: Puglia.

PLATE V, FIG. 2.

Spike straight or nearly so; chaff smooth, white; grain amber, inclining to red; beards white or straw-colored; beak of keel five to six times as long as broad; shoulder of outer glume broad, not sharply auriculate; grain short and broad.

This wheat is supposed to be of Spanish origin. It is now widely cultivated in all wheat-growing countries bordering on the Mediterranean. Under the name "Puglia," it is one of the best-known wheats of Italy. It is well known commercially and widely cultivated in Algeria, although often under purely local names. For both yield and quality it ranks among the best varieties grown in Algeria.

22

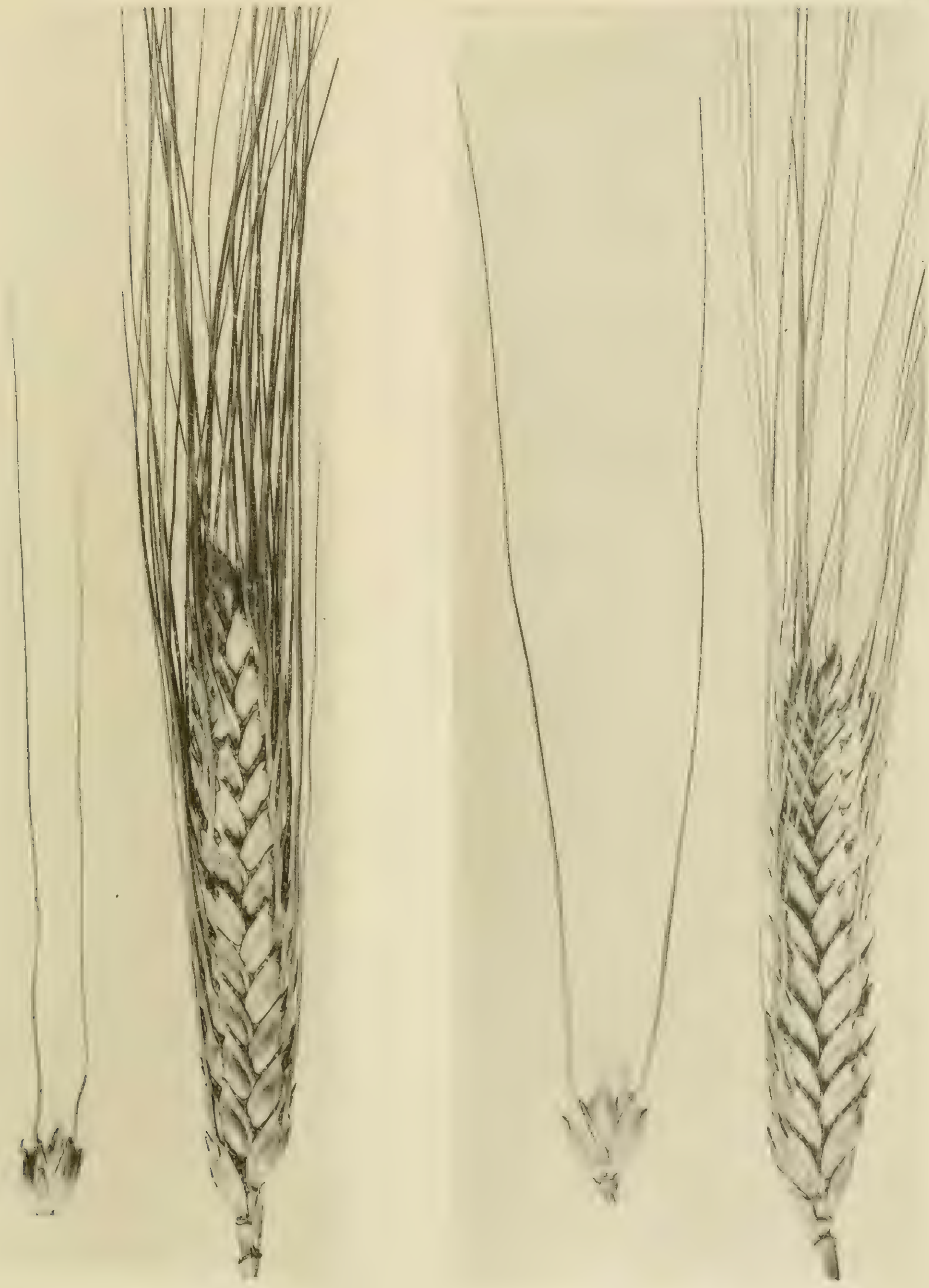

FIG. 1. FIG. 2.

[illegible] WHEATS. [illegible]

POULOT.

PLATE VI, FIG. 1.

Spike straight or nearly so; chaff smooth, white; grain clear amber; beards white or straw-colored; beak of keel two to four times as long as broad, distinctly passing the tip of the flowering glume; spikes about 1 cm. broad; spikelets bearing two or three grains.

This variety is grown to a limited extent in the southern part of the province of Algiers. It is named after the man on whose property it was found. It is not widely grown in Algeria, and is not commercially known. The grain is very large and of excellent quality.

PAROS. Synonyms: Atelante; Grece volo.

PLATE VI, FIG. 2.

Spike straight or nearly so; chaff smooth, red; grain amber, very slender, and pointed; spike about the same size from base to tip; beards brown, vigorous, and well retained; spikes about 1 cm. broad; spikelets bearing usually two grains; shoulder of outer glume very narrow, slightly auriculate.

This variety was introduced into Algeria from Greece. It is of very good quality, but has never attained a prominent place in general culture. Hairy-chaffed strains of this variety are not uncommon, the variety known as "El Hamra" being probably closely related to this one.

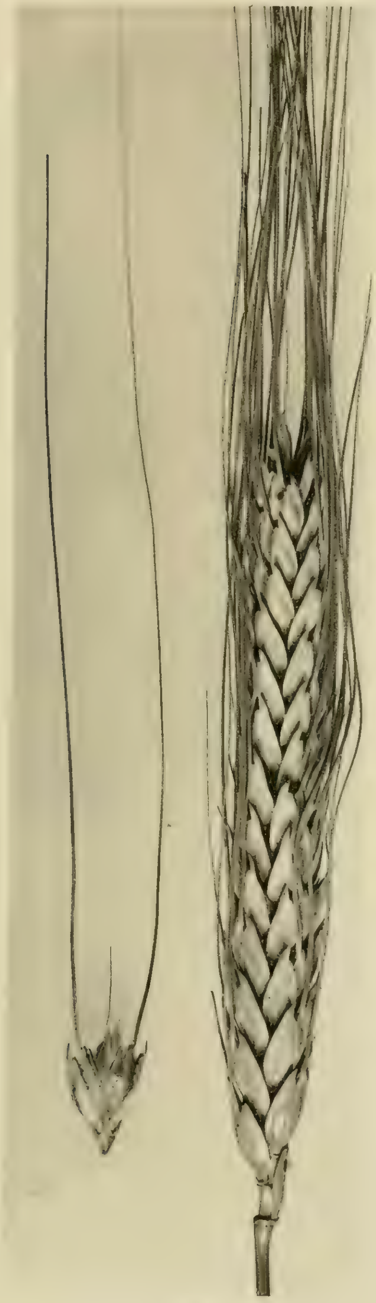

FIG. 1.

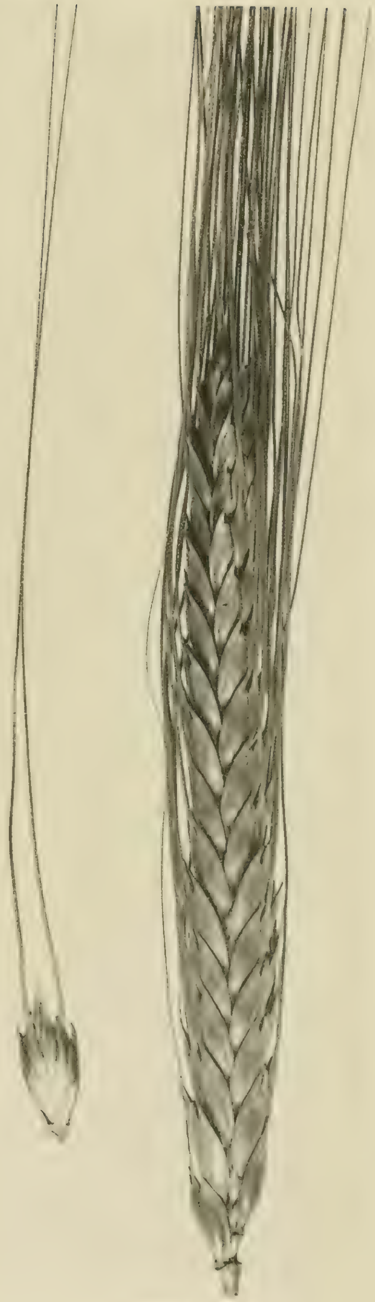

FIG. 2.

DURUM WHEATS: FIG. 1, POULOT; FIG. 2, PAROS.

HELIOTYPE CO., BOSTON.

BELIOUNI.

PLATE VII, FIG. 1.

Spike straight or nearly so; chaff smooth, red; grain clear amber, rather large; beards brown or black, vigorous, and well retained; spike about 1.2 cm. broad, nearly the same size from base to tip; spikelets bearing three or four grains; shoulder of outer glume broad, sharply auriculate. (See also Pl. II, fig. 1.)

This variety is well known on the high plateau of the province of Constantine in the vicinity of Setif; it is doubtless indigenous to that region. It has a vigorous habit of growth and produces grain of excellent quality.

MEDEAH.

PLATE VII, FIG. 2.

Spike straight or nearly so; chaff smooth, red, inclining to black; grain large but short, clear amber; beards brown or black, inclining to break off as the plant nears maturity; spike tapering decidedly from base to tip.

This variety is doubtless indigenous to Algeria. It takes its name from a town near the center of the province of Algiers, near which it is almost the only variety cultivated. It is known commercially as one of the superior sorts for the manufacture of macaroni. In the western part of the province of Oran, where it has been recently introduced, it matures nearly two weeks in advance of the other varieties cultivated there and yields well, producing grain of excellent quality. It is one of the most prominent varieties in Algeria.

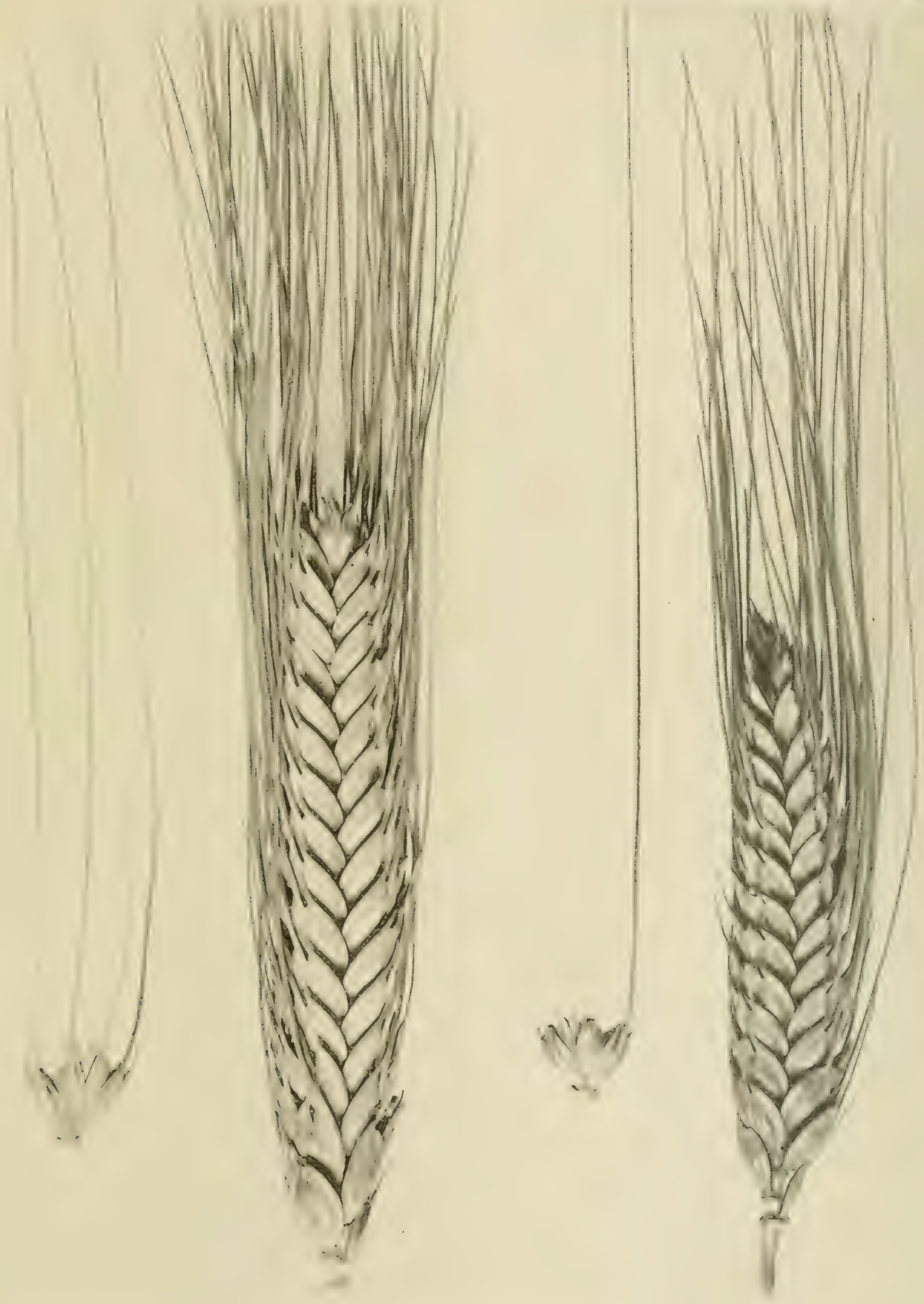

FIG. 1.

FIG. 2.

DURUM WHEATS: FIG. 1, BELIOUNI; FIG. 2, MEDEAH.

HELIOTYPE CO., BOSTON.

CAÏD DE SIOUF.

Plate VIII, Fig. 1.

Spike straight or nearly so; chaff smooth, black; grain dull amber, inclining to white; beards black; spike rather small, usually about 6 cm. long.

This variety is the product of selection made by an Arab, "Caïd," whose name it bears. While the grain is of rather large size, neither its quality nor the vigor of the plant is such as to gain for this variety a very large place in general culture in Algeria.

KAHLA. Synonyms: Maraouni; Madona.

Plate VIII, Fig. 2.

Spike straight or nearly so; chaff black; grain clear reddish amber; beards black; spike about 8 cm. long.

This wheat is grown in Algeria under a wide variety of names and conditions. It is a favorite with the Arabs. The name "Kahla" signifies black, in reference to the color of the chaff, which, however, varies somewhat with the conditions of light and atmospheric moisture. The plant is hardy and vigorous, growing with irrigation in the edge of the Sahara, and without irrigation on the high plateaus. The name "Madona" is attached to a strain of this variety, which is of Grecian origin. This variety has probably a wider distribution in Algeria than any other.

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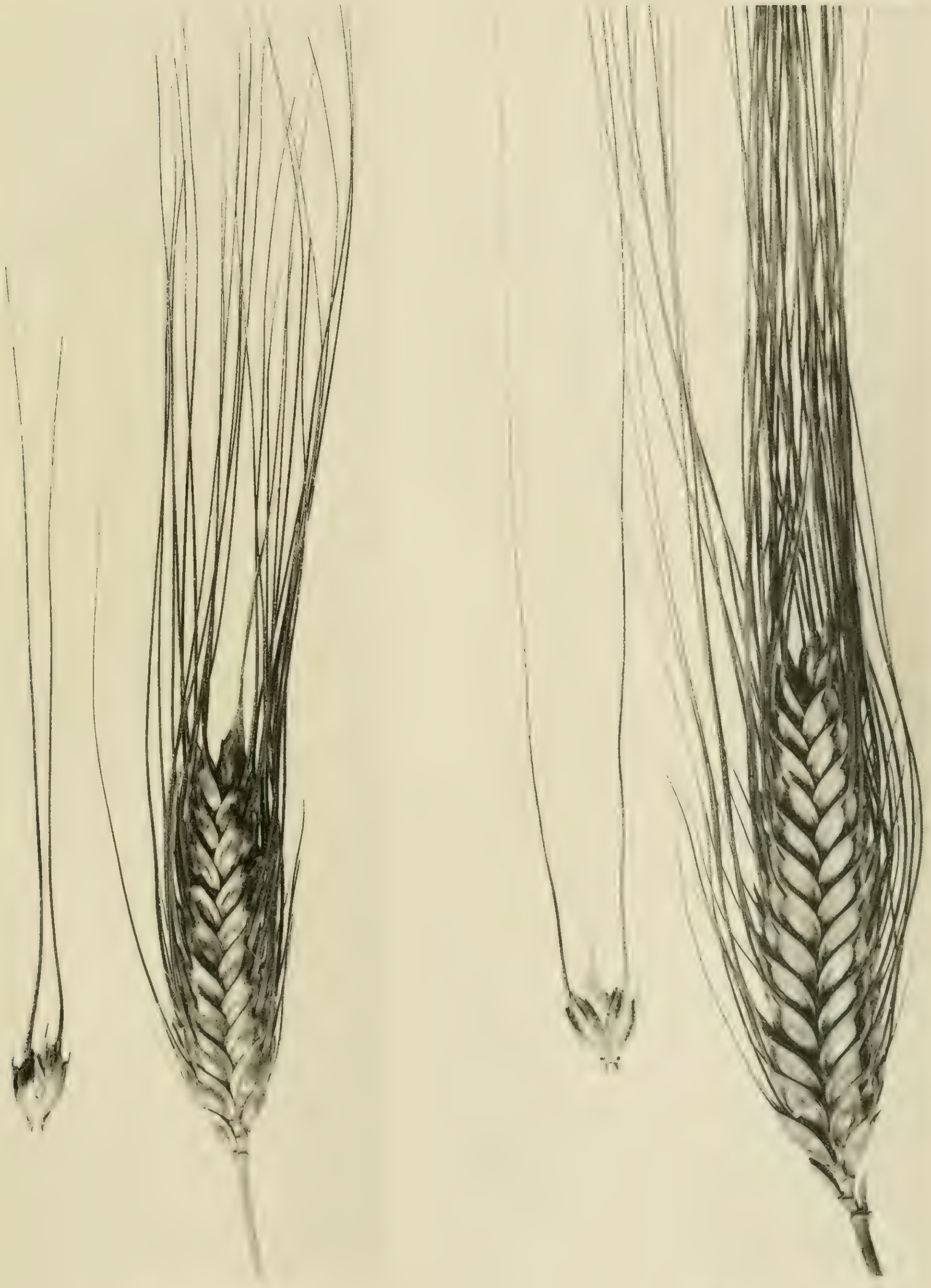

FIG. 1. FIG. 2.

DURUM WHEATS: FIG. 1, [illegible]; FIG. 2, [illegible].

HELIOTYPE CO., BOSTON

TRIMENIA.

PLATE IX, FIG. 1.

Spike straight or nearly so; chaff smooth, white; grain small, dull red; spike about 8 mm. broad, the least compact of all the Algerian durums; beak of keel five to six times as long as broad; shoulder of outer glume narrow, distinctly auriculate.

This variety is a native of Sicily, and has not been grown in Algeria except in an experimental way. Its chief value lies in its early maturity, from which it takes its name, "Trimenia" signifying three months. In the countries bordering the Mediterranean on the north this variety is grown with spring planting. The grain closely resembles in appearance the best Russian durums, and the Sicilian wheat is extensively used for making the superior grades of macaroni in Naples and Genoa.

HACHED. Synonym: Chetla.

PLATE IX, FIG. 2.

Spike straight or nearly so; chaff smooth, slightly reddish; grain clear red; spike about 1.1 cm. long; beak of keel three or four times as long as broad; shoulder of outer glume broad, not sharply auriculate.

This variety is one of the most important of the few red-grained kinds cultivated in Algeria, where amber-grained wheats are more generally sought after. It is cultivated chiefly on the higher lands of the province of Constantine, where it is frequently found. It is not of enough importance to find its way into commerce under its own name.

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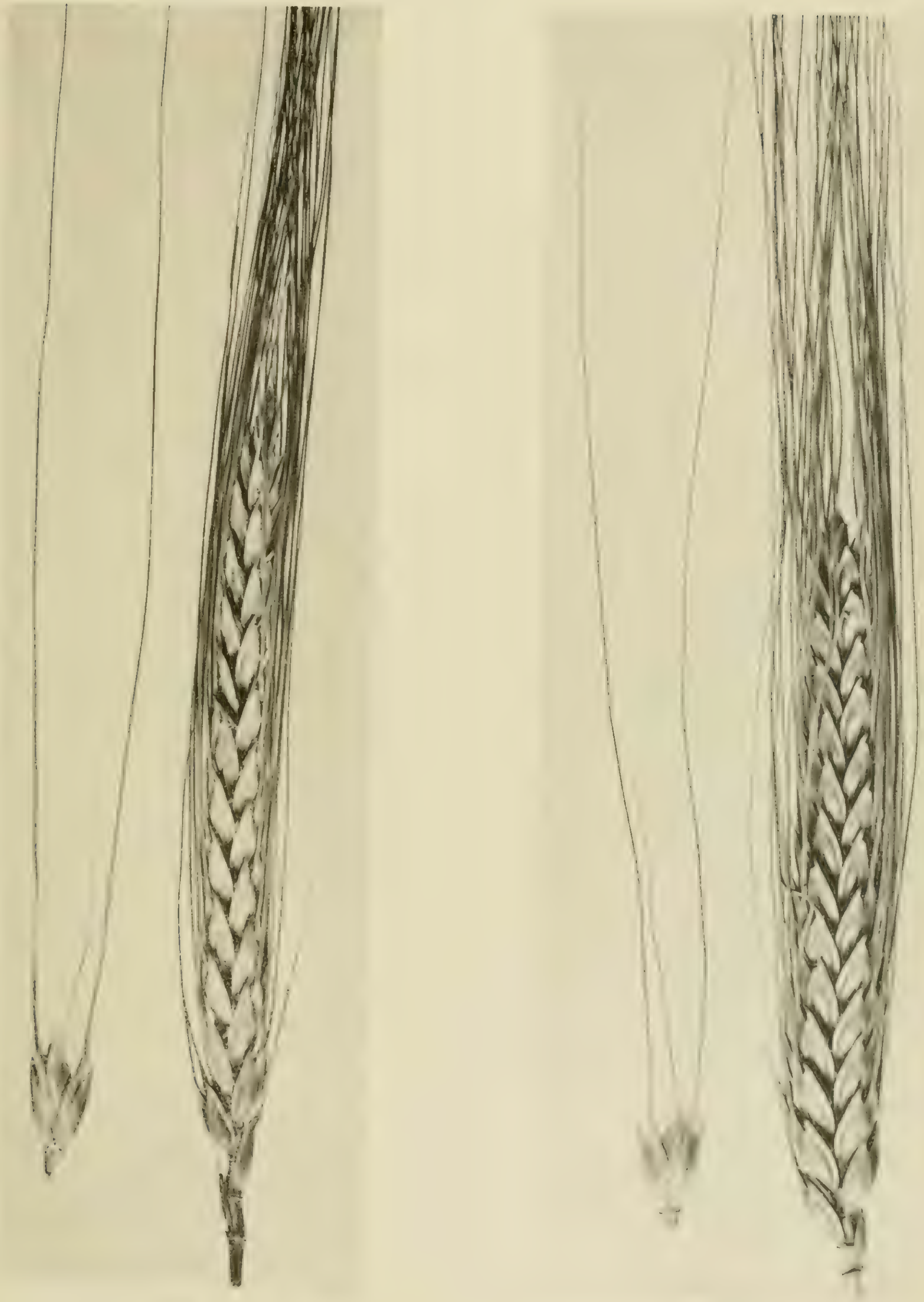

FIG. 1. FIG. 2.

DURUM WHEATS: FIG. 1, TRIMENIA; FIG. 2, HACHED.

HELIOTYPE CO., BOSTON.

BOGHAR. Synonym: Maroc Rebat.

Plate X, Fig. 1.

Spike straight or nearly so; chaff more or less hairy; grain red, short and broad; spike gradually tapering toward the tip, but not perceptibly flattened.

This variety is probably of Spanish origin. It has not been cultivated in Algeria except in an experimental way, though the quality of the grain is very good indeed. It is said to be cultivated to some extent in Morocco under the name of "Rebat."

EL AOUDJA. Synonym: Sbaa el Roumia.

Plate X, Fig. 2.

Spike straight or nearly so; chaff more or less hairy, white; grain red, long, slender, and pointed; spike slightly tapering toward the tip, distinctly flattened.

This variety is extensively cultivated under various names in the mountains of Kabylia, where it does fairly well, even under the adverse conditions of very slovenly culture which often prevail in this locality. The name "Sbaa el Roumia," by which it is often known, means "the finger of a Christian," in reference to the general shape and color of the spike. The form of spike and habit of growth somewhat resemble the "Nab el Bel" or "Richi" wheat. The latter, however, has the grain of a clear amber color, so that no confusion should arise between the two.

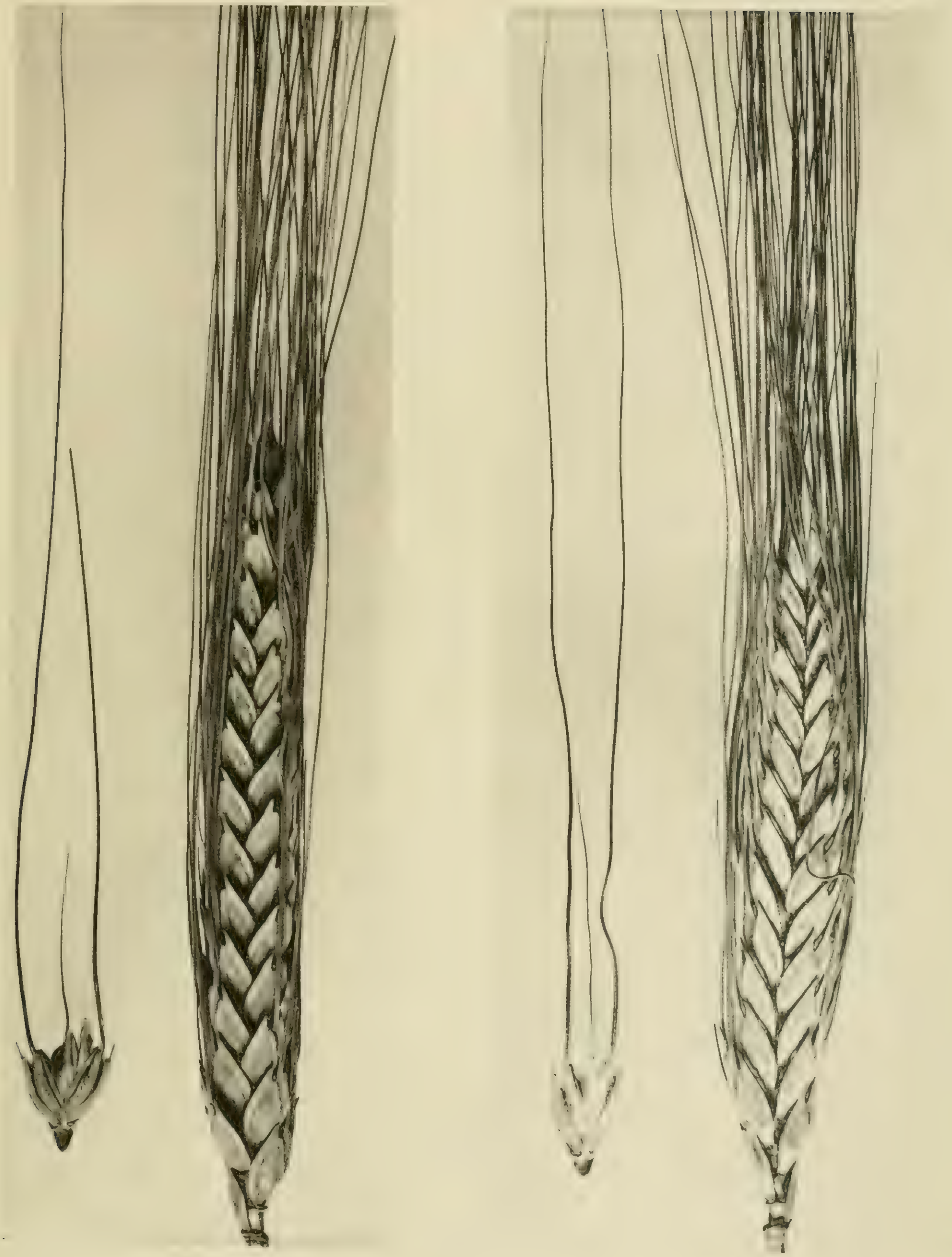

FIG. 1.

FIG. 2.

DURUM WHEATS: FIG. 1, BOGHAR; FIG. 2, EL AOUDJA.

HELIOTYPE CO., BOSTON.

TESDOUNI.

Plate XI, Fig. 1.

Spike straight or nearly so; chaff hairy, nearly white; grain red; spike somewhat club-shaped.

This is one of the many kinds of wheat cultivated by the Arabs in the Aures Mountains of the province of Constantine, Algeria. The spike is sometimes slightly curved, but the arrangement of the spikelets is not such as to class this variety with those having curved spike and exposed rachis. In general form, however, the spike often closely resembles that of the variety described later under the name "Zedouni;" in fact, the present variety may be considered as a variation from that. It is very vigorous and maintains itself well, even on the thin, poorly cultivated soils of the region where it grows. The grain is large and of excellent quality, but it seldom finds its way into commerce under its true variety name. A wheat closely resembling this and probably of the same variety has been found in Morocco.

M'SAKEN.

Plate XI, Fig. 2.

Spike straight or nearly so; chaff more or less hairy, nearly or quite white; beards white or straw-colored; spike barely if at all flattened; beak of keel blunt, about as broad as long; grain small, clear amber.

This variety is probably of Tunisian origin and is adapted to very dry conditions. It is, so far as is known, not widely cultivated in Algeria. Its name would indicate that it is considered by the Arabs to be one of the original types of wheat.

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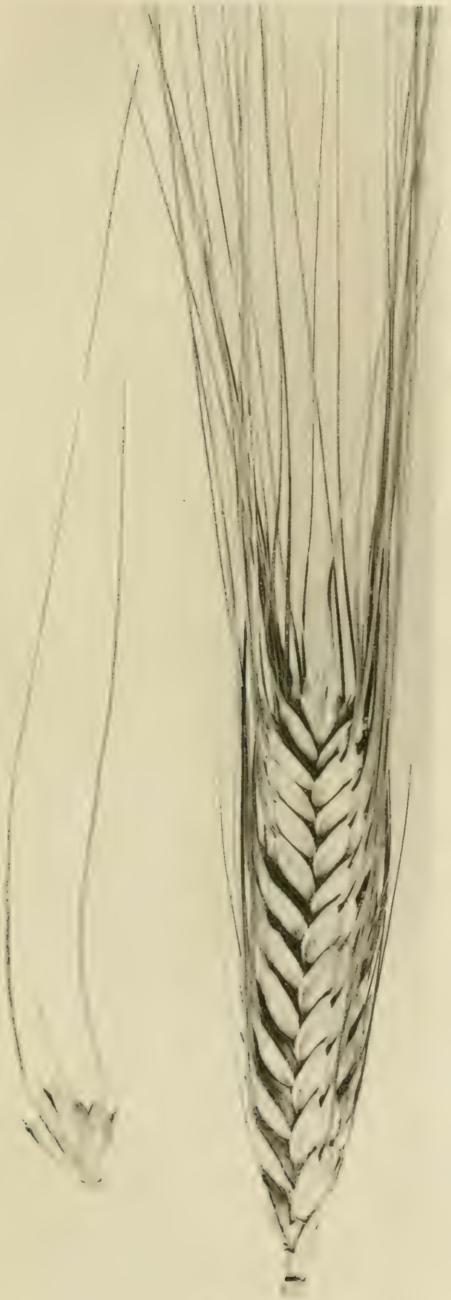

FIG. 1.

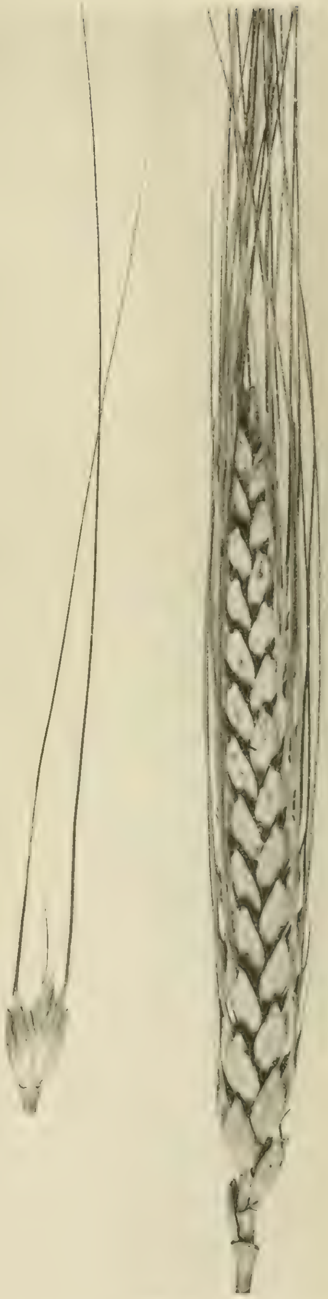

FIG. 2.

DURUM WHEATS: FIG. 1, TESDOUNI; FIG. 2, M'SAKEN.

HELIOTYPE CO., BOSTON.

MEDEBA.

PLATE XII, FIG. 1.

Spike straight or nearly so; chaff hairy, white; grain clear amber, large, blunt; spike barely if at all flattened; beak of keel sharp, two or three times as long as broad; beards white or straw-colored.

This variety is one of the many found in the Aures Mountains of the province of Constantine. The name signifies "humpbacked," in reference to the peculiar shape of the berry. The wheat is not widely known either in culture or commerce, but is a vigorous sort and produces grain of very good quality.

MESKIANA. Synonyms: Djenah au Necar; Abd el Kader.

PLATE XII, FIG. 2.

Spike straight or nearly so; chaff more or less hairy, white; grain clear amber, large, short, and broad; beards white or straw-colored; spike distinctly flattened, about 1.1 cm. broad; shoulder of outer glume slightly or not at all auriculate. (See also Pl. III, fig. 2.)

This variety of wheat takes its name from a town in the province of Constantine, Algeria. It is commonly grown by the Arabs in the Aures Mountains, but under various names, which suggest good qualities for it, although it has not, so far as is known, attracted special attention in either culture or commerce.

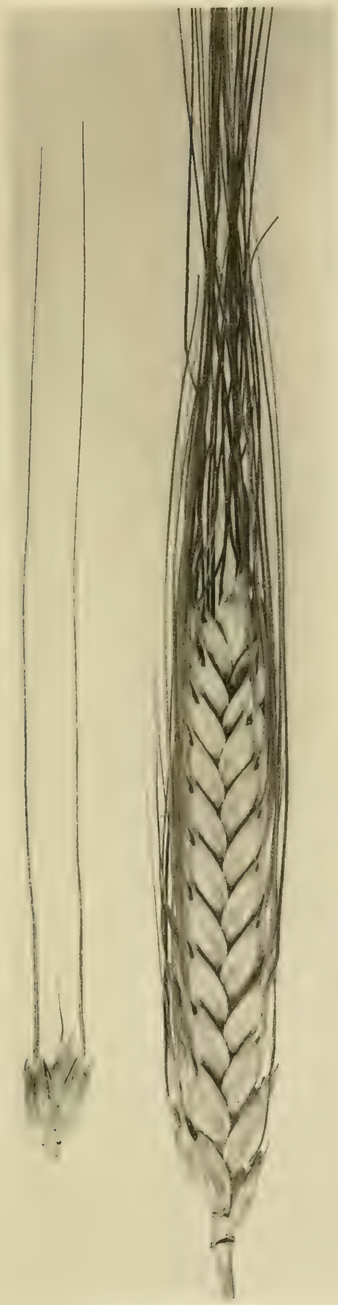

FIG. 1.

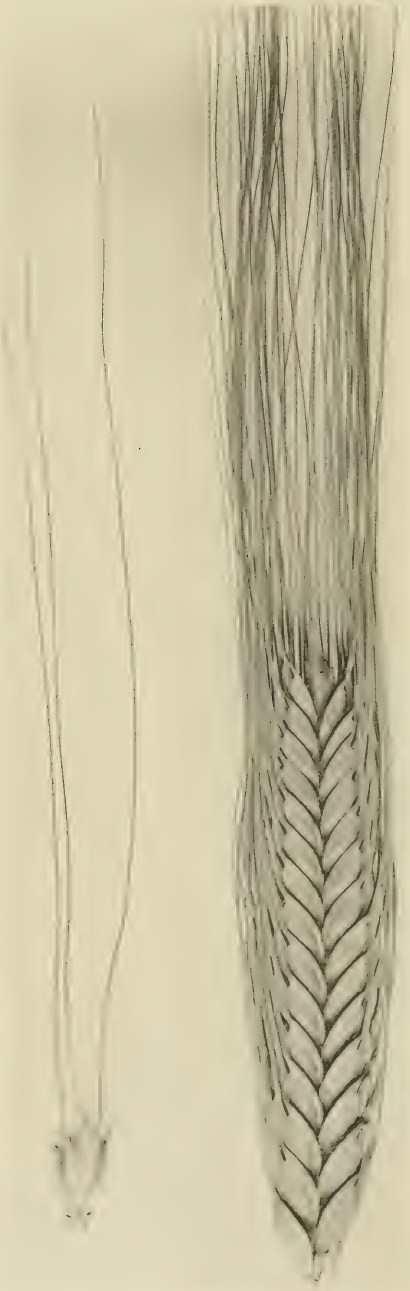

FIG. 2.

DURUM WHEATS: FIG. 1, MEDEBA; FIG. 2, MESKIANA.

HELIOTYPE CO., BOSTON.

CAÏD ELEUZE.

PLATE XIII, FIG. 1.

Spike more or less curved; rachis nearly or quite exposed on the curved side; chaff more or less hairy, white; beards very strong, nearly or quite black; grain clear amber, very large. (See also Pl. I.)

This variety, which takes its name from an Arab officer, is noticeable chiefly for the large size of its grain. It is grown on the high plateau of the province of Constantine, but has not a wide distribution. It is not known in commerce.

PELISSIER. Synonym: Hebda.

PLATE XIII, FIG. 2.

Spike straight or nearly so; chaff white, hairy, though in some strains nearly or quite smooth; grain dull amber, inclining to white; beards black.

This variety, presumably of Spanish origin, is widely distributed throughout North Africa, where it is grown under many different names. The chief name is taken from a man living near "Ponts des Issers," in the western part of the province of Oran, who did some valuable work in selection to improve the yield of the variety. There is in this variety considerable variation, or else there are several distinct varieties that closely resemble this one in general appearance. The predominant type is as described above, but it is not uncommon to find wheat identical with this except for a smooth chaff. It is difficult to decide whether or not this characteristic is sufficient to make a variety distinction. Pelissier wheat is now attracting attention on account of its superior yielding qualities. It is gaining a considerable place in general culture in the western part of the province of Algiers, and has shown itself to be one of the best yielding and most rust-resisting varieties that have been tried at the botanical experimental station at Rouiba, Algeria.

MOHAMED BEN BACHIR. Synonym: Makouwi.

PLATE XIII, FIG. 2.

This variety so closely resembles the preceding one, except in the color of the chaff, that the same cut may illustrate both. (See also Pl. II, fig. 2.) It is said that the original seed of this plant was brought from Mecca (hence the name "Makouwi") by an Arab, from whom it is named "Mohamed ben Bachir." The latter is much the more common name. The variety is a favorite in the province of Constantine, near Setif, which is one of the largest primary wheat markets in Algeria. The wheat is extensively known both in culture and in commerce.

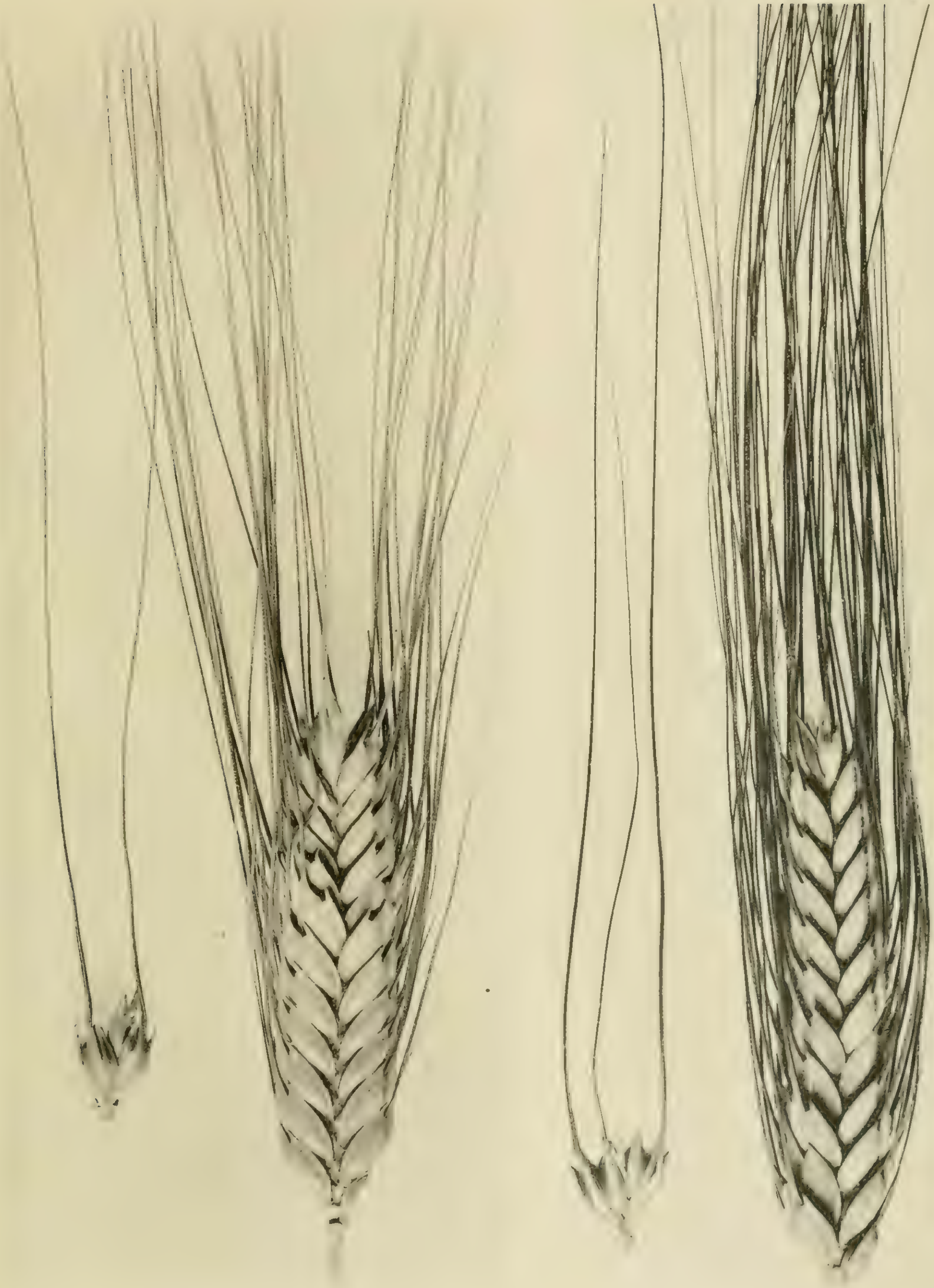

FIG. 1. FIG. 2.

DURUM WHEATS: FIG. 1, SAID ELEUZE; FIG. 2, PELISSIER.

HELIOTYPE CO., BOSTON.

EL HAMRA. Synonym: Russian.

PLATE XIV, FIG. 1.

Spike straight or nearly so; chaff more or less hairy, red or slightly brown; grain clear amber, slender and pointed; beards straw-colored or red; beak of keel passing tip of flowering glume; shoulder of outer glume narrow, slightly auriculate.

The name of this variety refers to the general color of the spike, signifying "the red." It is probable that some seed of Russian origin has produced a similar variety, which accounts for the synonym. This wheat is widely distributed in Algeria, but is by no means as extensively grown as some of the other sorts. It is easily possible to confuse this variety with "Paros," previously mentioned, which differs from it only in having a smooth chaff. The similarity between the two sorts extends to the shape and color of the grain.

AZIZI.

PLATE XIV, FIG. 2.

Spike straight or nearly so; chaff more or less hairy, red or slightly brown; beards straw-colored or red; grain large, clear amber; beak of keel hardly reaching tip of flowering glume; shoulder of outer glume broad, sharply auriculate.

This variety is said to have been brought into Algeria from Tunis. So far as is known, it has not gained a prominent place in general culture.

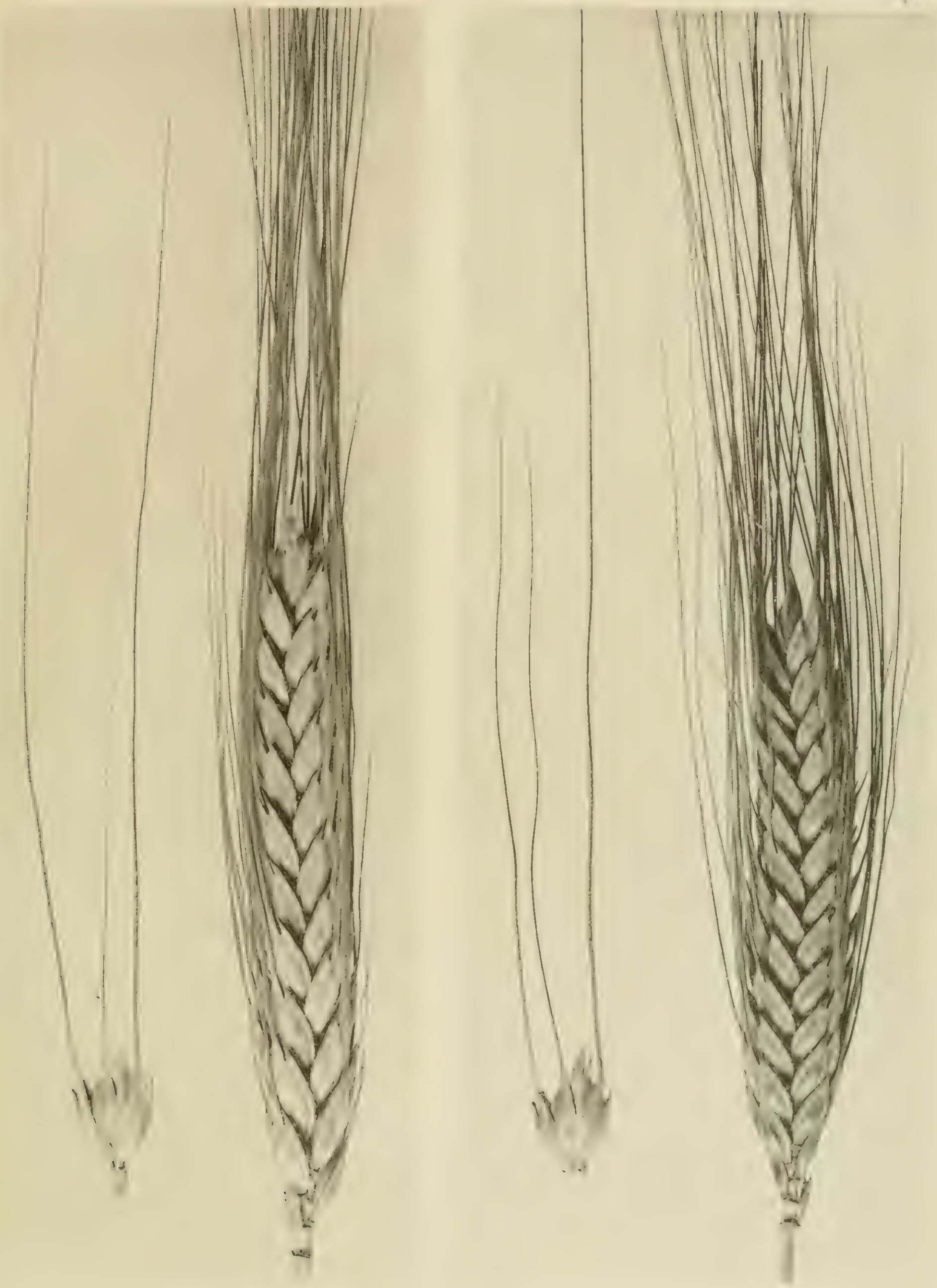

FIG. 1.

FIG. 2.

DURUM WHEATS: FIG. 1, EL HAMRA; FIG. 2, AZIZI.

HELIOTYPE CO., BOSTON.

MAROC.

PLATE XV, FIG. 1.

Spike straight or nearly so; chaff more or less hairy, red or slightly brown; grain long, pointed, amber inclining to red; beards black; shoulder of outer glume reduced to a slender tooth; chaff often streaked with black.

This variety has been brought into Algeria from Morocco and tried in an experimental way. It has not so far found a place in general culture. It is, however, a distinct type and for that reason retains a place in this list.

OUCHDA.

PLATE XV, FIG. 2.

Spike more or less curved; chaff hairy; beards straw-colored, very strong; glumes often long but never reaching 2 cm. in length; spike tapering decidedly in the upper half, 8 to 10 cm. long; grain very light, clear amber; beards inclining to black.

This is one of the types commonly found in mountainous regions. It is very vigorous and is popular where wheat culture is carried on under adverse conditions. It is supposed to have originated in Morocco, but has been tried to some extent in Algeria.

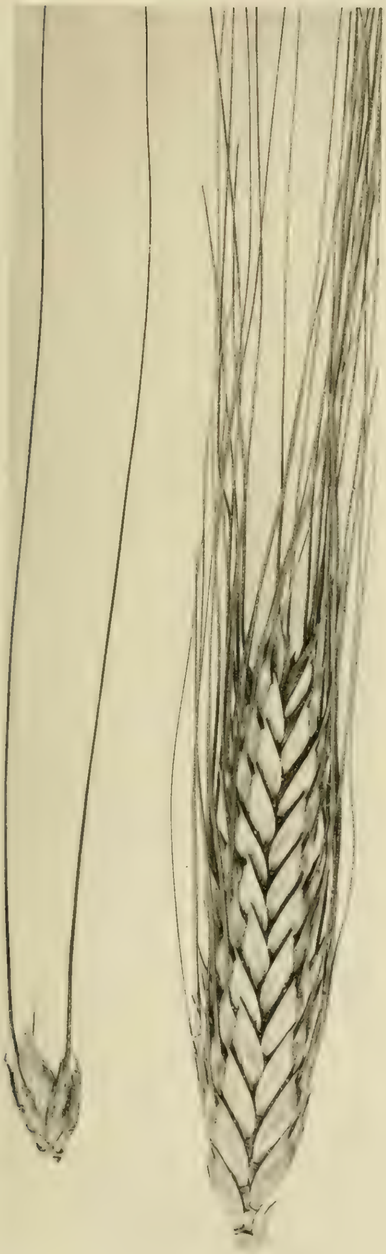

FIG. 1.

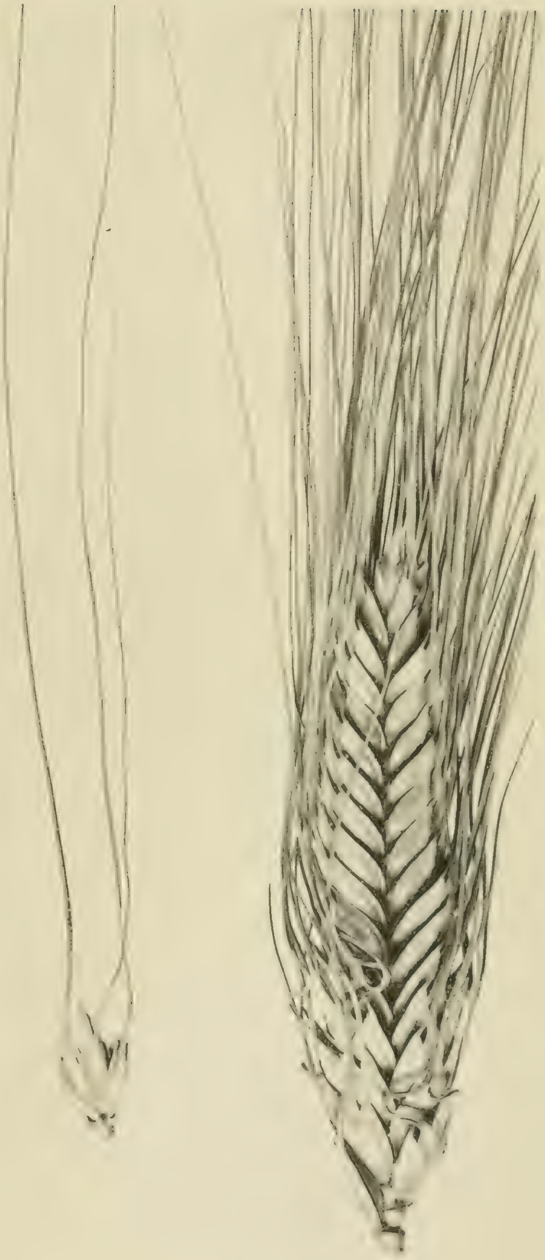

FIG. 2.

DURUM WHEATS: FIG. 1, MAROC; FIG. 2, OUCHDA.

AURES.

PLATE XVII, FIG. 1.

Spike more or less curved; chaff hairy; beards strong, straw-colored, glumes often very long, but never reaching 2 cm. in length; spikelets set almost at right angles to the rachis, making the spike about 2.2 cm. broad, nearly the same breadth throughout its length; grain very large, clear amber.

This variety is grown extensively on the lower lands of Algeria from seed obtained from the Aures Mountains, from which it takes its name. It is a very vigorous sort, producing grain of unusual size and very good quality. In the Aures Mountains it is grown under a variety of local names.

MOROCCAIN.

PLATE XVII, FIG. 2.

Spike straight or nearly so; chaff smooth, nearly or quite white; beards white or straw-colored, sometimes rather weak; beak of keel five to six times as long as broad; shoulder of outer glume narrow, sharply auriculate; grain clear amber, long and pointed. (See also Pl. III, fig. 1.)

This wheat, which comes from Morocco, is so far not widely cultivated in Algeria. It is interesting chiefly as showing one of the connecting links between the species *T. durum* and *T. polonicum*. Plants of this variety readily vary toward the type of either species. In both yield and quality of the grain it is considered to be inferior to the regular durum sorts.

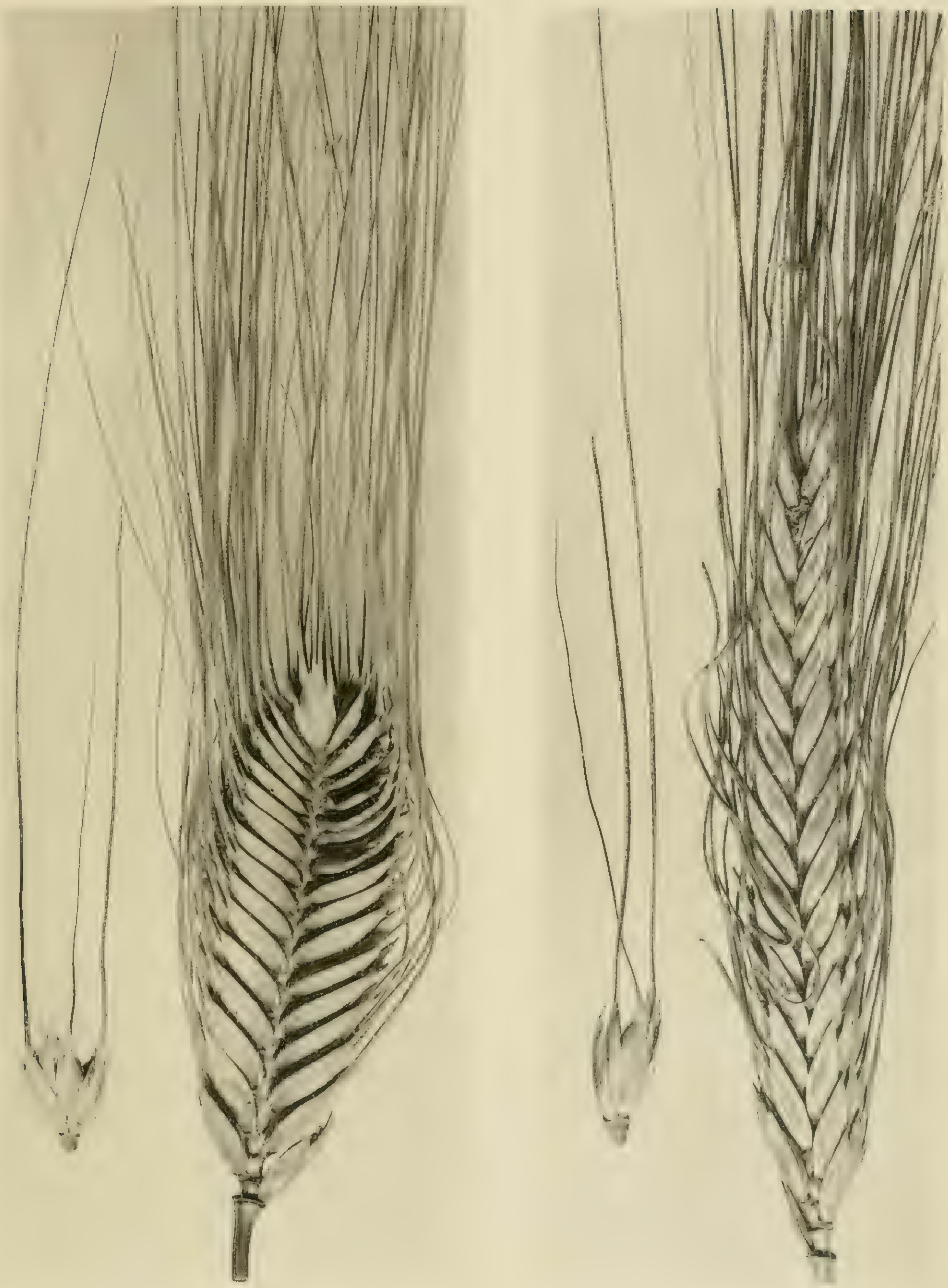

FIG. 1. FIG. 2.

DURUM WHEATS: FIG. 1, AURES: FIG. 2, MOROCCAIN.

HELIOTYPE CO., BOSTON.

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NAB EL BEL. Synonyms: Richi; Mahmoudi; Gemgoun; Montenotte; El Beliouni; Sbaa el Roumia; El Aoudja.

PLATE XVIII, FIG. 1.

Spike straight, or nearly so; chaff hairy, white; glumes rather long, but never reaching 2 cm. in length; spike distinctly flattened, about 1.5 cm. broad; shoulder of outer glume sharply auriculate; grain clear amber, long and slender, very large, often curved. (See also Pl. III, fig. 2.)

This is probably the most common variety of wheat in eastern Algeria, as its numerous names show. These names for the most part refer to the long, curved shape of the grain, "Nab el Bel" meaning "the eye tooth of a male camel;" "Gemgoun," the "beak of a vulture;" but "Richi," meaning "like a plume," applies to the general shape of the spike. Wheats closely similar to this are widely cultivated in Tunis, Greece, and Egypt. The glumes of this variety are soft and parchment-like, and under a change of conditions the variety may readily sport toward the type of *T. polonicum*. When the variety is kept up, however, by careful selection it stands as one of the most important and best known of the Algerian durums. It is hardy and vigorous, will do well under a wide variety of conditions, and produces grain of extra large size and good quality.

EL SAFRA.

PLATE XVIII, FIG. 2.

Spike more or less curved; chaff smooth, soft and parchment-like; glumes usually more than 2 cm. long; palea about one-half as long as flowering glumes; beards white or straw-colored, sparse and weak; grain amber, very long, slender and pointed.

This variety is, so far as is known, of no great cultural or commercial value. The plants do not seem vigorous and the quality of the grain is not of the highest. The type is used here chiefly to show one of the extremes of variation found in the species *T. durum*. Hybrids between this and other species of wheat have given both interesting and valuable results. This is one of the radical types of wheat and the variation induced by crossing it with other varieties is very great.

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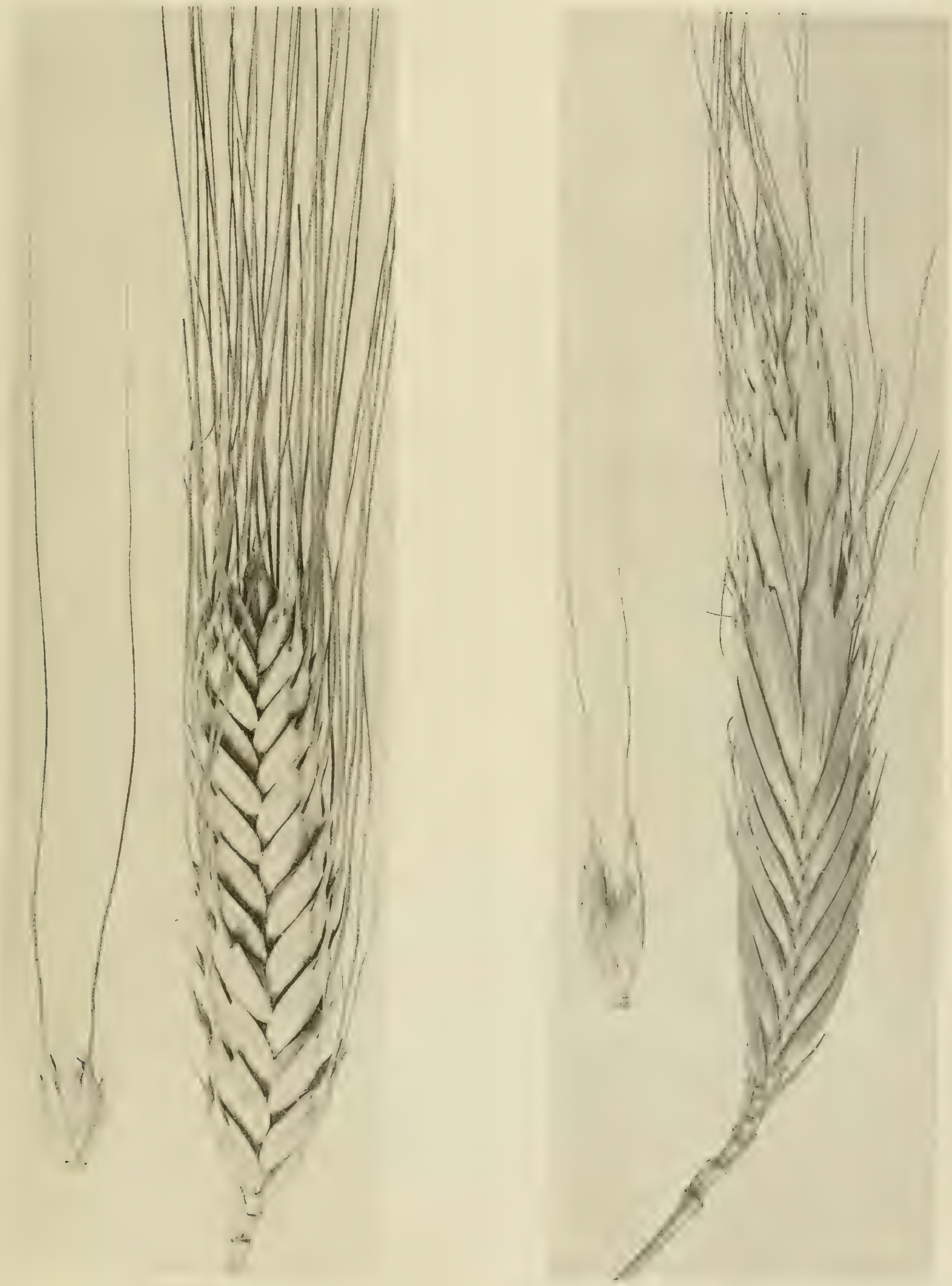

FIG. 1. FIG. 2.

DURUM WHEATS: FIG. 1, NAB EL BEL; FIG. 2, EL SAFRA.

HELIOTYPE CO., BOSTON.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN No. 8.

B. T. GALLOWAY, Chief of Bureau.

A COLLECTION OF ECONOMIC AND OTHER FUNGI

PREPARED FOR DISTRIBUTION.

BY

FLORA W. PATTERSON, Mycologist,
VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

Issued February 3, 1902.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., November 7, 1901.

Sir: I have the honor to transmit herewith a paper entitled A Collection of Economic and other Fungi, prepared by Mrs. Flora W. Patterson, of Vegetable Pathological and Physiological Investigations, and submitted by the Pathologist and Physiologist. It is respectfully recommended that the paper be published as Bulletin No. 8 of this Bureau.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

This Office has for some time had in contemplation a distribution of its duplicate material to the various State agricultural experiment stations, and now offers to them and other interested workers such specimens as they may select from the list which follows. It is greatly to be regretted that all species represented in this list are not in sufficient quantity to permit the distribution to be made to the experiment stations at least in uniform sets.

Each State agricultural experiment station is invited to compile its own set and to select from this list fifty specimens, which we will forward on request, but if preferred the selection will be made here. All specimens desired over fifty may be considered as in exchange. Accounts will be opened with any station so that it may avail itself at once of this material, even if it is not yet in position to send the exchanges for specimens selected in excess of the fifty furnished free. Experiment station workers will be enabled by this means to add to their reference collections with but slight expense and trouble. There are, of course, many things common in certain parts of the country which are either rare or do not occur in other parts. We would like to get all kinds of material, whether common or not. Aid is solicited toward making this exchange a success.

In establishing this exchange it is desired to extend its benefits not only to experiment station workers, but to specialists and all who are interested in the study of fungi from the economic standpoint.

The arrangement proposed is to exchange specimen for specimen when those offered are well preserved, of good quality, in abundant quantity, and authentically determined, labeled, and already placed in mycological envelopes.

In regard to exchanges for undetermined specimens and material in bulk requiring preparation for herbarium use, arrangements will be made by correspondence.

The attention of specialists is called to the desirability of having *type* specimens of at least all American species deposited in the herbarium of this Office, where they will always be accessible to those interested.

Address all correspondence to Mycological Exchange, Bureau of Plant Industry, Department of Agriculture, Washington, D. C.

ALBERT F. WOODS,
Pathologist and Physiologist.

OFFICE OF THE PATHOLOGIST AND PHYSIOLOGIST,
Washington, D. C., October 24, 1901.

B P. I.—10 V. P. P. I.—91

A COLLECTION OF ECONOMIC AND OTHER FUNGI PREPARED FOR DISTRIBUTION.

By Flora W. Patterson, *Mycologist.*

INTRODUCTION.

An examination of this list will show the collection to be geographically very limited. It is hoped by the method now proposed to interest a large number of botanists whose collections may help ours to become more general in its nature and enable others to materially enhance the value of their herbaria at small expense. Advanced students in agricultural colleges may, under the directions of their instructors, be able to collect and contribute valuable material that will thus be made available to other workers and at the same time acquire a choice nucleus for their own herbaria. This plan will also accomplish the purpose of an exchange bureau for fungi which will be free from the awkward limitations of the usual exchange bureau. It will be easily adapted to the individual needs and circumstances of all classes interested.

Much unidentified material is at hand to be worked up which, together with what is expected to be received in response to this issue, will warrant the publication of an additional catalogue as soon as the work can be accomplished. The attempt will be made in the future, as has been with this distribution, to verify all determinations, and no effort will be spared to make the collections as authentic as published sets of exsiccati. Species have been carefully compared with their types when such were available. Duplicates of all these specimens may be examined in our herbarium.

The general arrangement and the nomenclature of the fungi are in the main that of Saccardo's Sylloge Fungorum, and the nomenclature of the hosts is from Farlow and Seymour's Host Index and Hooker and Jackson's Index Kewensis. Names marked with an asterisk (*) are from the Index Kewensis. The above works are the ones used for general reference and the arrangement of our herbarium. No attempt has been made to keep strictly up to date with the rearrangement of groups by recent monographers, as an exchange like the present may much more appropriately adhere to standard works which are probably accessible to all.

UREDINEÆ.

1. **Æcidium abundans** Pk.
   Symphoricarpus occidentalis. Nebraska.
2. **Æcidium apocyni** Schw.
   Apocynum cannabinum. Virginia.
3. **Æcidium clematidis** DC.
   a. Clamatis ligusticifolia. Nebraska.
   b. Clematis virginiana. Missouri.
4. **Æcidium compositarum** Mart.
   a. Artemisia ludoviciana. Montana.
   b. Helianthus sp. Missouri.
   c. Prenanthes alba. Minnesota.
   d. Solidago sp. District of Columbia, Missouri.
   *e. Solidago bicolor.** District of Columbia.
5. **Æcidium cressæ** DC.
   *Cressa truxillensis.** California.
6. **Æcidium euphorbiæ** Schw.
   Euphorbia preslii. Nebraska.
7. **Æcidium fraxini** Schw.
   a. Fraxinus sp. Massachusetts.
   b. Fraxinus americana. District of Columbia.
8. **Æcidium gerardiæ** Pk.
   Gerardia quercifolia. Michigan.
9. **Æcidium houstoniatum** Schw.
   *Houstonia minima.** Texas.
10. **Æcidium hydnoideum** B. & C.
    Dirca palustris. Indiana.
11. **Æcidium hypericatum** Schw.
    Ascyrum crux-andreæ. Mississippi.
12. **Æcidium impatientis** Schw.
    Impatiens pallida. Missouri; Virginia.
13. **Æcidium ludwigiæ** Ell. & Ever.
    *Ludwigia hirtella.** Mississippi.
14. **Æcidium lycopi** Gerard.
    Lycopus virginicus. Maryland.
15. **Æcidium peckii** De Toni.
    Œnothera biennis. Iowa.
16. **Æcidium pteleæ** B. & C.
    Ptelea trifoliata. Missouri.
17. **Æcidium ranunculacearum** DC.
    a. Anemone cylindrica. Nebraska.
    b. Ranunculus abortivus. Maryland.
18. **Æcidium rœstelioides** Ell. & Ever.
    Sidalcea malvaeflora. Colorado.
19. **Æcidium sambuci** Schw.
    Sambucus canadensis. Virginia.
20. **Æcidium smilacis** Schw.
    Smilax herbacea. Nebraska.
21. **Æcidium thalictri flavi** (DC.) Wint.
    Thalictrum fendleri. Colorado.
22. **Æcidium verbenæ** Speg.
    Verbena stricta. Nebraska.
23. **Æcidium xanthoxyli** Pk.
    Xanthoxylum americanum. Missouri.
24. **Calyptospora gœppertiana** Kühn.
    a. Vaccinium ovatum. Washington.
    *b. Vaccinium parvifolium.** Washington.
25. **Chrysomyxa albida** Kühn.
    *a. Rubus cuneifolius.** Indiana.
    b. Rubus villosus. Illinois, Indiana, Kansas.
26. **Chrysomyxa pirolæ** (DC.) Rostrup.
    Pirola rotundifolia. District of Columbia, Massachusetts.
27. **Coleosporium ipomœæ** (S.) Burrill.
    a. Ipomœa sp. Texas.
    b. Ipomœa pandurata. Illinois.
28. **Coleosporium pini** Galloway.
    Pinus inops. Maryland.
29. **Coleosporium sonchi-arvensis** (P.) Lév.
    a. Aster sp. Ohio, Vermont.
    b. Aster cordifolius. Indiana.
    c. Aster foliaceus var. *eatoni.* Montana.
    d. Aster macrophyllus. Michigan.
    e. Aster novæ-angliæ. Indiana.
    f. Aster paniculatus. Indiana.

29. **Coleosporium sonchi-arvensis** (P.) Lév.—Continued.
  g. *Aster puniceus.* Indiana.
  h. *Aster sagittifolius.* Illinois, Indiana, Nebraska.
  i. *Aster shortii.* Indiana.
  j. *Aster tradescanti.* Indiana.
  k. *Solidago* sp. District of Columbia, Illinois, Maryland.
  l. *Solidago arguta.* Indiana.
  m. *Solidago cæsia.* Indiana.
  n. *Solidago canadensis.* Indiana.
  o. *Solidago latifolia.* Indiana.
  p. *Solidago patula.** Illinois, Indiana.
  q. *Solidago pauciflosculosa.** Mississippi.
  r. *Solidago rugosa.* Indiana.
  s. *Solidago serotina.* Indiana.
  t. *Vernonia fasciculata.* Illinois, Missouri.
  u. *Vernonia noveboracensis.* Indiana.

30. **Cronartium asclepiadeum** (Willd.) Fr. var. **quercuum** Cke.
  Quercus sp. Maryland.

31. **Cronartium asclepiadeum** (Willd.) Fr. var. **thesii** Berk.
  a. *Comandra pallida.* Montana, Nebraska.
  b. *Comandra umbellata.* Illinois.

32. **Gymnosporangium bermudianum** (Farl.) Earle. I.
  Juniperus virginiana. Mississippi.

33. **Gymnosporangium clavariæforme** (Jacq.) Rees. I.
  a. *Cratægus apiifolia.* Indiana.
  b. *Cratægus coccinea.* Indiana, Michigan.
  c. *Cratægus crus-galli.* Indiana.
  d. *Cratægus spathulata.* Indiana.
  e. *Cratægus tomentosa.* Illinois, Michigan.
  f. *Pirus coronaria.* Illinois.
  g. *Pirus malus.* District of Columbia, Maryland, New Jersey, North Carolina.

34. **Gymnosporangium clavipes** C. & P. I.
  a. *Cratægus* sp. (cult.). District of Columbia.
  b. *Cratægus coccinea.* Mississippi.

35. **Gymnosporangium ellisii** (B.) Farl. III.
  Chamæcyparis sphæroidea. Massachusetts.

36. **Gymnosporangium globosum** Farl. III.
  Juniperus virginiana. Massachusetts.

37. **Gymnosporangium macropus** Lk. I.
  a. *Pirus coronaria.* Indiana.
  b. *Pirus malus.* New Jersey.

38. **Gymnosporangium macropus** Lk. III.
  Juniperus virginiana. District of Columbia.

39. **Gymnosporangium nidus-avis** Thaxter. I.
  Pirus malus. Indiana.

40. **Melampsora betulina** (P.) Tul.
  Betula populifolia. Massachusetts.

41. **Melampsora farinosa** (P.) Schröt.
  a. *Salix* sp. Arizona, Illinois, Massachusetts, Michigan, Montana, Nebraska, Virginia.
  b. *Salix cordata.* Montana.
  c. *Salix flavescens.* Washington.
  d. *Salix longifolia.* Montana.
  e. *Salix rostrata.* Montana.

42. **Melampsora hydrangeæ** (B. & C.) Farl.
  Hydrangea arborescens. District of Columbia, Illinois, Indiana, West Virginia.

43. **Melampsora lini** (P.) Desm.
  a. *Linum perenne.* Colorado, Montana.
  b. *Linum rigidum.* Montana.

44. **Melampsora populina** (Jacq.) Lév.
  a. *Populus angustifolia.* Montana.
  b. *Populus balsamifera* var. *candicans.* Indiana.

44. **Melampsora populina** (Jacq.) Lév.—Continued.

c. Populus grandidentata. Indiana.

d. Populus monilifera. Illinois, Indiana.

e. Populus tremuloides. Montana.

45. **Melampsorella cerastii** (P.) Schröt.

Cerastium arvense. Montana.

46. **Peridermium pini** Lév.

a. Pinus sp. Georgia, Missouri.

b. Pinus mitis. Maryland.

47. **Phragmidium potentillæ** (P.) Karst.

a. Potentilla dissecta. Montana.

b. Potentilla gracilis. Nebraska.

c. Potentilla pennsylvanica. Montana.

48. **Phragmidium rubi-idæi** (P.) Wint.

a. Rubus strigosus. Massachusetts.

b. Rubus villosus. West Virginia.

49. **Phragmidium speciosum** Fr.

a. Rosa sp. West Virginia.

b. Rosa lucida. Mississippi.

50. **Phragmidium subcorticium** (Schrk.) Wint.

a. Rosa sp. Illinois.

b. Rosa arkansana. Montana.

c. Rosa hemispherica. Nebraska.

d. Rosa lucida. Illinois, Indiana.

*e. Rosa nutkana.** Washington.

*f. Rosa setigera.** Indiana.

51. **Puccinia aletridis** B. & C.

Aletris farinosa. Massachusetts.

52. **Puccinia amphigena** Dietel.

*Ammophila longifolia.** Montana.

53. **Puccinia andropogonis** Schw.

a. Andropogon furcatus. Illinois.

b. Andropogon hallii. Nebraska.

53. **Puccinia andropogonis** Schw.—Continued.

c. Andropogon scoparius. Illinois, Iowa, Mississippi.

54. **Puccinia angustata** Pk.

a. Eriophorum cyperinum. Illinois.

b. Eriophorum virginicum. Massachusetts.

c. Scirpus sp. West Virginia.

d. Scirpus atrovirens. Indiana.

55. **Puccinia apocrypta** Ell. & Tracy.

Asprella hystrix. Indiana.

56. **Puccinia argentata** (Schultz) Wint.

a. Impatiens fulva. Indiana, Virginia.

b. Impatiens pallida. West Virginia.

57. **Puccinia asparagi** DC.

Asparagus officinalis. New Jersey.

58. **Puccinia asteris** Duby.

a. Aster sp. District of Columbia, Missouri.

b. Aster cordifolius. Indiana.

c. Aster paniculatus. Indiana.

d. Aster shortii. Illinois.

59. **Puccinia balsamorrhizæ** Pk.

Balsamorrhiza sagittata. Montana.

60. **Puccinia caricis** (Schum.) Reb.

a. Carex sp. Illinois, Indiana, Maryland, West Virginia.

*b. Carex bullata.** Indiana.

*c. Carex fœnea.** Indiana.

*d. Carex lupulina.** Indiana.

e. Carex pennsylvanica. Montana.

*f. Carex stipata.** Montana.

g. Carex straminea var. *sperta.* Montana.

h. Carex straminea var. *mirabilis.* Indiana.

*i Carex virescens.** Indiana.

*j Carex vulpinoidea.** Michigan.

61. **Puccinia caulicola** Tracy & Gall.

Unknown labiate. New Mexico.

62. **Puccinia circææ** Pers.

Circæa lutetiana. Illinois, Indiana, Michigan.

63. **Puccinia conoclinii** Seymour.
Eupatorium sp. Illinois.
Eupatorium cœlestinum. West Virginia.

64. **Puccinia coronata** Cda.
Avena sativa. Kansas.
*Holcus lanatus.** Mississippi.

65. **Puccinia convolvuli** (P.) Cast.
Convolvulus sepium. Illinois, Michigan.
*Convolvulus spithamæus.** Minnesota.

66. **Puccinia cyperi** Arthur.
Cyperus sp. Illinois, Michigan, Texas.
*Cyperus erythrorhizos.** Michigan.

67. **Puccinia dayi** Clinton.
Steironema ciliatum. Indiana.

68. **Puccinia distichlydis** Ell. & Ever.
Distichlis maritima. Montana.

69. **Puccinia eleocharidis** Arthur.
*Eleocharis ovata.** West Virginia.

70. **Puccinia emaculata** Schw.
a. Panicum capillare. Illinois.
b. Panicum virgatum. West Virginia.
c. Triodia cuprea. Illinois, Missouri, West Virginia.

71. **Puccinia epilobii** DC.
Œnothera biennis. Maryland, New Hampshire.

72. **Puccinia flaccida** B. & Br.
Panicum crus-galli. Illinois.

73. **Puccinia fusca** (Relh.) Wint.
a. Anemone nemorosa. Massachusetts, Wisconsin.
b. Anemone patens var. *nuttalliana.* Colorado.

74. **Puccinia galii** (P.) Wint.
a. Galium aparine. Missouri.
b. Galium asprellum. Indiana, West Virginia.
c. Galium concinnum. Illinois, Indiana.
d. Galium triflorum. Nebraska.

75. **Puccinia gayophyti** Pk.
Gayophytum ramosissimum. Arizona.

76. **Puccinia gentianæ** (Str.) Lk.
Gentiana andrewsii. Michigan.

77. **Puccinia glechomatis** DC.
Lophanthus nepetoides. Illinois.

78. **Puccinia gonolobi** Rav.
*a. Gonolobus hirsutus.** Mississippi.
*b. Vincetoxicum palustre.** Mississippi.

79. **Puccinia graminis** Pers. I.
*Berberis vulgaris.** New Jersey.

80. **Puccinia graminis** Pers. II & III.
*a. Agropyrum dasystachyum.** Michigan.
b. Agrostis alba var. *vulgaris.* Illinois, West Virginia.
c. Avena sativa. Kansas.
d. Hordeum jubatum. Illinois.
e. Poa compressa. Indiana.
f. Poa pratensis. Indiana.

81. **Puccinia grindeliæ** Pk.
Grindelia sp. Colorado.

82. **Puccinia heliopsidis** Schw.
a. Heliopsis lævis. Minnesota.
*b. Heliopsis scabra.** Indiana.

83. **Puccinia heterogenea** Lagh.
Malva sp. Ecuador.

84. **Puccinia heterospora** B. & C.
Sida spinosa. Mississippi, Missouri.

85. **Puccinia hieracii** (Schum.) Mart.
a. Bidens bipinnata. California.
b. Cnicus undulatus. Montana.
c. Crepis sp. Colorado.
d. Taraxacum officinale. Illinois, Massachusetts, New Jersey.

86. **Puccinia hyptidis** (Curt.) Tracy & Earle.
Hyptis radiata. Mississippi.

87. **Puccinia hysteriiformis** Pk.
Arenaria congesta, var. *subcongesta.* Montana.

88. **Puccinia intermixta** Pk.
Iva axillaris. Montana.

89. **Puccinia Jonesii** Pk.
Musenium tenuifolium. Nebraska.

90. **Puccinia kansensis** Ell. & Barthol. *Buchlœ dactyloides.* Kansas.

91. **Puccinia kuhniæ** Schw.
  Kuhnia eupatorioides. Colorado, Illinois.

92. **Puccinia lateripes** B. & Rav.
  a. Ruellia ciliosa. Illinois.
  b. Ruellia strepens. Illinois, Indiana.

93. **Puccinia malvacearum** Mont.
  Althæa rosea. California.

94. **Puccinia malvastri** (Farl.) Pk.
  Malvastrum coccineum. New Mexico.

95. **Puccinia mariæ-wilsoni** Clint.
  Claytonia virginica. District of Columbia.

96. **Puccinia menthæ** Pers.
  *a. Blephilia ciliata.** District of Columbia.
  b. Blephilia hirsuta. Indiana, Iowa.
  c. Cunila mariana. District of Columbia.
  d. Mentha canadensis. Illinois, Indiana, Washington.
  e. Mentha canadensis var. *glauca.* Montana.
  f. Monarda sp. Illinois.
  g. Monarda fistulosa. Illinois, Indiana, Nebraska.
  h. Monarda punctata. Minnesota.
  i. Pycnanthemum linifolium. Illinois.

97. **Puccinia mesomegala** B. & C.
  *Clintonia uniflora.** Idaho.

98. **Puccinia miconiæ** Lagh.
  Miconia sp. Ecuador.

99. **Puccinia microsperma** B. & C.
  Lobelia syphilitica. Indiana.

100. **Puccinia nardosmii** Ell. & Ever.
  Petasites palmata. Canada.

101. **Puccinia ornata** Arth. & Holw.
  Rumex britannica. New Hampshire.

102. **Puccinia peckiana** Howe.
  a. Rubus sp. Delaware, Missouri, New Jersey.
  b. Rubus strigosus. Kansas.
  c. Rubus villosus. District of Columbia, Kansas.

103. **Puccinia phragmitis** (Schum.) Körn.
  Spartina cynosuroides. Illinois, Montana.

104. **Puccinia pimpinellæ** (Str.) Lk.
  a. Chærophyllum procumbens. District of Columbia, Virginia.
  b. Osmorrhiza sp. Ohio, Virginia.
  c. Osmorrhiza brevistylis. Wisconsin.

105. **Puccinia poarum** Niels.
  Poa pratensis. Indiana.

106. **Puccinia podophylli** Schw.
  Podophyllum peltatum. District of Columbia, Indiana, Mississippi, Missouri, Pennsylvania.

107. **Puccinia polygoni-amphibii** Pers.
  a. Polygonum sp. Montana.
  b. Polygonum amphibium. Illinois, Virginia.
  c. Polygonum hartwrightii. Illinois.
  d. Polygonum virginianum. District of Columbia, Illinois, Michigan.

108. **Puccinia pruni-spinosæ** Pers.
  a. Prunus sp. Kansas.
  b. Prunus americana. Illinois, Kansas, West Virginia, Texas.
  c. Prunus armeniaca. California.
  d. Prunus hortulana. Texas.
  e. Prunus persica. California, Georgia.
  f. Prunus serotina. District of Columbia, Iowa.

109. **Puccinia purpurea** Cke.
  Sorghum saccharatum. Texas.

110. **Puccinia rubigo-vera** (DC.) Wint.
  a. Agropyrum divergens. Montana.
  b. Agropyrum repens. New Jersey.

110. **Puccinia rubigo-vera** (DC.) Wint.—Continued.
 *c. Agropyrum tenerum.** Montana.
 d. Avena sativa. Indiana.
 e. Elymus virginicus. Illinois.
 f. Poa sp. Montana.
 g. Secale cereale. New Jersey.
 h. Triticum vulgare. Missouri.
 i. Triticum vulgare var. *Zimmerman.* Kansas.

111. **Puccinia saxifragæ** Schl.
 a. Heuchera cylindrica. Montana.
 b. Saxifraga virginiensis. District of Columbia.

112. **Puccinia schœleriana** Plow. & Magnus.
 *Carex stenolepis.** Indiana.

113. **Puccinia seymeriæ** Burrill.
 *a. Gerardia tenuifolia.** Illinois.
 b. Seymeria macrophylla. Illinois.

114. **Puccinia silphii** Schw.
 Silphium perfoliatum. Illinois, Iowa.

115. **Puccinia smilacis** Schw.
 Smilax sp. District of Columbia, Mississippi.

116. **Puccinia sorghi** Schw.
 a. Zea mays. Illinois, Michigan.
 b. Tripsacum dactyloides. Kansas.

117. **Puccinia sporoboli.** Arthur.
 Sporobolus asper. Mississippi.

118. **Puccinia stipæ** Arthur.
 Stipa comata. Montana.

119. **Puccinia suaveolens** (P.) Rostrup.
 a. Cnicus arvensis. New Jersey.
 b. Cnicus lanceolatus. Indiana.

120. **Puccinia subnitens** Dietel.
 Distichlis maritima. New Mexico, South Dakota.

121. **Puccinia tanaceti** DC.
 a. Artemisia cana. Montana, Nebraska.

121. **Puccinia tanaceti** DC.—Continued.
 b. Artemisia dracunculoides. Montana.
 c. Artemisia tridentata. Montana.
 d. Helianthus sp. District of Columbia, Illinois.
 e. Helianthus annuus. Idaho, Illinois, Indiana, Montana.
 f. Helianthus divaricatus. Indiana.
 g. Helianthus grosse-serratus. Illinois, Nebraska.
 h. Helianthus lætiflorus. Nebraska.
 i. Helianthus petiolaris. Montana, Nebraska.
 j. Helianthus strumosus. Indiana, Virginia.
 k. Helianthus tracheliifolius. Indiana.

122. **Puccinia tanaceti** DC., var. **vernoniæ** (S.) Burrill.
 Vernonia fasciculata. Nebraska.

123. **Puccinia variolans** Hark.
 Aplopappus spinulosus. Montana.

124. **Puccinia veratri** Duby.
 Veratrum californicum. Colorado.

125. **Puccinia verbesinæ** Schw.
 a. Verbesina sp. West Virginia.
 b. Verbesina occidentalis. West Virginia.

126. **Puccinia violæ** (Schum.) DC.
 a. Viola sp. Maryland.
 b. Viola cucullata. Indiana.
 c. Viola striata. Indiana.

127. **Puccinia windsoriæ** Schw.
 a. Muhlenbergia sp. Illinois.
 b. Muhlenbergia mexicana. Kansas.

128. **Puccinia xanthii** Schw.
 a. Ambrosia trifida. Illinois, Minnesota.
 b. Xanthium canadense. Indiana.
 *c. Xanthium strumarium.** Indiana, Maryland.

129. **Pucciniastrum crotonis** (Burr.) De Toni.
Croton capitatus. Missouri.

130. **Pucciniastrum epilobii** (Chaill.) Otth.
a. *Epilobium* sp. Montana.
b. *Epilobium coloratum.* Montana, Nebraska.

131. **Ravenelia cassiæcola** Atk.
*Cassia nictitans.** Mississippi.

132. **Ravenelia glandulæformis** B. & C.
Tephrosia virginiana. Illinois, West Virginia.

133. **Ravenelia opaca** (Sey. & Earle) Dietel.
Gleditschia triacanthos. Illinois.

134. **Triphragmium clavellosum** Berk.
Aralia nudicaulis. Maine.

135. **Triphragmium echinatum** Lév.
Oenanthe californica. California.

136. **Uredinopsis scolopendrii** (Fckl.) Dietel.
Onoclea sensibilis. Massachusetts.

137. **Uredo agrimoniæ** (DC.) Schröt.
a. *Agrimonia eupatoria.* Illinois, Indiana, Minnesota, Nebraska.
b. *Agrimonia parviflora.* West Virginia.

138. **Uredo cassandræ** Pk. & Clint.
Cassandra calyculata. Michigan.

139. **Uredo cherimoliæ** Lagh.
Anona cherimolia. Ecuador.

140. **Uredo fici** Cast.
Ficus carica. Mississippi.

141. **Uredo oxalidis** Lév.
Oxalis violacea. Texas.

142. **Uredo oxytropidis** (Pk.) De Toni.
Oxytropis lamberti. Montana.

143. **Uromyces andropogonis** Tracy.
Andropogon virginicus. Mississippi.

144. **Uromyces appendiculatus** (P.) Lk.
a. *Phaseolus* sp. Mississippi, New Jersey.
b. *Phaseolus diversifolius.* Indiana.
c. *Phaseolus pauciflorus.* Illinois, Missouri.
d. *Phaseolus perennis.* Indiana.
e. *Phaseolus vulgaris.* Illinois.

145. **Uromyces argophyllæ** Seymour.
Psoralea argophylla. North Dakota.

146. **Uromyces aristidæ** Ell. & Ever.
*Aristida oligantha.** Illinois.

147. **Uromyces caladii** (S.) Farl.
a. *Arisæma dracontium.* Maryland, Missouri.
b. *Arisæma triphyllum.* District of Columbia, Indiana, Maryland, Michigan.
c. *Peltandra undulata.* Michigan, Virginia.
d. *Pontederia cordata.* Missouri.

148. **Uromyces caryophyllinus** (Schrk.) Schröt.
*Dianthus caryophyllus.** District of Columbia.

149. **Uromyces eriogoni** Ell. & Hark.
*Eriogonum microthecum?** Montana.

150. **Uromyces euphorbiæ** C. & P.
a. *Euphorbia hypericifolia.** Illinois.
b. *Euphorbia serpyllifolia.* Montana.

151. **Uromyces fabæ** (P.) De By.
a. *Lathyrus* sp. Michigan, Minnesota, West Virginia.
b. *Lathyrus polymorphus.* Nebraska.

152. **Uromyces genestæ-tinctoriæ** (P.) Fckl.
Colutea arborescens. Kansas.

153. **Uromyces glycyrrhizæ** (Rabh.) Magnus.
Glycyrrhiza lepidota. California, Montana.

154. **Uromyces graminicola** Burrill.
- *a. Glyceria fluitans.* Illinois.
- *b. Panicum virgatum.* Illinois.

155. **Uromyces hedysari-paniculati** (S.) Farl.
- *a. Desmodium* sp. District of Columbia, Illinois, Mississippi.
- *b. Desmodium canescens.* Missouri.
- *c. Desmodium paniculatum.* Illinois, Indiana.

156. **Uromyces howei** Pk.
- *a. Asclepias cornuti.* Illinois, Indiana, West Virginia.
- *b. Asclepias incarnata.* Iowa, West Virginia.
- *c. Asclepias purpurascens.** Indiana.

157. **Uromyces hyperici** (S.) Curt.
- *a. Hypericum canadense.** Indiana.
- *b. Hypericum mutilum.* West Virginia.
- *c. Hypericum paludosum.** Illinois.

158. **Uromyces jonesii** Pk.
Ranunculus alismæfolius var. *alismellus.* California.

159. **Uromyces junci** (Desm.) Tul.
- *a. Juncus effusus.* West Virginia.
- *b. Juncus longistylis.* Montana.
- *c. Juncus tenuis.* Illinois.

160. **Uromyces lespedezæ** (S.) Pk.
- *a. Lespedeza capitata.* Illinois, Michigan.
- *b. Lespedeza polystachya.** Missouri, West Virginia.
- *c. Lespedeza repens.* District of Columbia, Colorado, Illinois, Indiana.
- *d. Lespedeza reticulata.** Indiana.
- *e. Lespedeza stuvei.** Missouri.

160. **Uromyces lespedezæ** (S.) Pk.—Continued.
- *f. Lespedeza violacea.* Mississippi, Missouri, Virginia.

161. **Uromyces limonii** (DC.) Lév.
Statice limonium. Mississippi.

162. **Uromyces piriformis** Cke.
Acorus calamus. Michigan.

163. **Uromyces polygoni** (P.) Fckl.
- *a. Polygonum* sp. Illinois, Indiana, Minnesota, Missouri.
- *b. Polygonum acre.* Illinois.
- *c. Polygonum aviculare.* Illinois.
- *d. Polygonum hydropiperoides.** Illinois.

164. **Uromyces rudbeckiæ** Arth. & Holw.
Rudbeckia laciniata. Illinois. Nebraska.

165. **Uromyces sophoræ** Pk.
Sophora sericea. Colorado.

166. **Uromyces spermacoces** (S.) Curt.
Diodia teres. Illinois, Missouri, Virginia.

167. **Uromyces terebinthi** (DC.) Wint.
Rhus toxicodendron. Indiana, Nebraska.

168. **Uromyces trifolii** (Hedw.) Wint.
- *a. Trifolium carolinianum.* Texas.
- *b. Trifolium medium.** Indiana.
- *c. Trifolium pratense.* Indiana, Massachusetts, New Jersey, New York.
- *d. Trifolium repens.* Michigan.

169. **Uromyces werneriæ** Lagh.
*Werneria nubigena.** Ecuador.

170. **Uropyxis amorphæ** (Curt.) Schröt.
- *a. Amorpha canescens.* Illinois.
- *b. Amorpha fruticosa.* Illinois, Mississippi.

171. **Uropyxis petalostemonis** (Farl.) De Toni.
Petalostemon candidus. Nebraska.

USTILAGINEÆ.

172. **Cerebella paspali** Cke. & Massee.
Panicum virgatum. Mississippi.

173. **Cintractia junci** (S.) Trel.
Juncus tenuis. Massachusetts.

174. **Entyloma compositarum** Farl.
a. *Ambrosia trifida.* District of Columbia, Missouri.
b. *Lepachys pinnata.* Iowa.

175. **Entyloma menispermi** Farl. & Trel.
Menispermum canadense. Illinois.

176. **Entyloma physalidis** (Kalch. & Cke.) Wint.
a. *Physalis philadelphica.* Indiana.
b. *Physalis virginiana.* Michigan.

177. **Entyloma ranunculi** (Bon.) Schröt, forma *thalictri* Farl.
Thalictrum purpurascens. Illinois.

178. **Entyloma saniculæ** Pk.
Sanicula marylandica. Iowa.

179. **Entyloma serotinum** Schröt.
*Mertensia pumonarioides?** Maryland.

180. **Graphiola phœnicis** (Moug.) Poit.
*Phœnix canariensis.** California.

181. **Sorosporium syntherismæ** (S.) Farl.
a. *Cenchrus tribuloides.* Illinois.
b. *Panicum proliferum.* Illinois.
c. *Panicum sanguinale.* Mississippi, Missouri.

182. **Sphacelotheca hydropiperis** (Schum.) De By.
Polygonum sagittatum. West Virginia.

183. **Urocystis agropyri** (Preuss.) Schröt.
Agropyrum repens. Massachusetts.

184. **Urocystis anemones** (P.) Schröt.
Anemone acutiloba. Iowa.

185. **Urocystis waldsteiniæ** Pk.
Waldsteinia fragarioides. New York.

186. **Ustilago austro-americana** Speg.
a. *Polygonum* sp. District of Columbia, Illinois, Missouri.
b. *Polygonum hydropiper.* District of Columbia.
c. *Polygonum pennsylvanicum.* Missouri.

187. **Ustilago avenæ** (P.) Jensen.
Avena sativa. Tennessee.

188. **Ustilago caricis** (P.) Fckl.
a. *Carex filifolia.* Montana.
b. *Carex pennsylvanica.* Montana.

189. **Ustilago diplospora** Ell. and Ever.
Panicum sanguinale. Mississippi.

190. **Ustilago lineata** Cke.
Zizania aquatica. Nebraska.

191. **Ustilago maydis** (DC.) Cda.
Zea Mays. Indiana.

192. **Ustilago minima** Arthur.
Stipa comata. Montana.

193. **Ustilago montaniensis** Ell. & Ever.
Muhlenbergia glomerata var. *setiformis.* Montana.

194. **Ustilago neglecta** Niessl.
a. *Setaria.* sp. Iowa.
b. *Setaria glauca.* Illinois, Massachusetts.

195. **Ustilago ornata** Tracy & Earle.
*Leptochloa mucronata.** Mississippi.

196. **Ustilago pustulata** Tracy & Earle.
Panicum proliferum. Mississippi.

197. **Ustilago rabenhorstiana** Kühn.
Panicum sanguinale. Maryland.

198. **Ustilago sorghi** (Lk.) Pass.
Sorghum vulgare. Kansas.

199. **Ustilago spermophora** B. & C.
a. Eragrostis major. Iowa.
b. Eragrostis minor. * Illinois.

200. **Ustilago tritici** (P.) Jensen.
Triticum vulgare. Michigan.

201. **Ustilago uniolæ** Ell. & Ever.
Uniola gracilis. Mississippi.

202. **Ustilago utriculosa** (Nees) Tul.
a. Polygonum sp. Illinois, Mississippi.
b. Polygonum pennsylvanicum. Illinois, Missouri, West Virginia.

203. **Tilletia corona** Scribner.
a. Leersia oryzoides. District of Columbia.
b. Leersia virginica. Illinois.
c. Panicum virgatum. Illinois.

204. **Tilletia horrida** Tak.
Oryza sativa. Japan.

PHYCOMYCETEÆ.

205. **Albugo amaranthi** (S.) Kuntze.
a. Amarantus albus. Montana.
b. Amarantus chlorostachys var. *hybridus.* Indiana.
c. *Amarantus retroflexus.* Indiana, Michigan.

206. **Albugo candida** (P.) Kuntze.
*a. Brassica alba.** Indiana.
b. Capsella bursa-pastoris. District of Columbia.

207. **Albugo ipomϾ-panduranæ** (S.) Swingle.
a. Ipomœa batatas. New Jersey.
b. Ipomœa pandurata Indiana, Missouri.

208. **Albugo platensis** (Speg.) Swingle.
*a. Boerhaavia erecta.** Florida.

208. **Albugo platensis** (Speg.) Swingle—Continued.
*b. Boerhaavia hirsuta?** Florida.

209. **Albugo portulacæ** (DC.) Kuntze.
Portulaca oleracea. District of Columbia.

210. **Albugo tragopogonis** (P.) S. F. Gray.
Ambrosia artemisiæfolia. New York.

211. **Bremia lactucæ** Regel.
a. Lactuca sp. Illinois, Maryland, West Virginia.
*b. Lactuca integrifolia.** Maryland.
c. Lactuca leucophæa. Maryland.
d. Lactuca sativa. Maryland.

212. **Peronospora alta** Fckl.
Plantago sp. Indiana.

213. **Peronospora arthuri** Farl.
Oenothera biennis. Maryland, Massachusetts.

214. **Peronospora calotheca** De By.
Galium triflorum. Wisconsin.

215. **Peronospora corydalis** De By.
*Corydalis glauca.** Massachusetts.

216. **Peronospora effusa** (Grev.) Rabh.
a. Chenopodium album. Indiana.
b. Spinacea oleracea. Rhode Island.

217. **Peronospora ficariæ** Tul.
Ranunculus acris. Massachusetts.

218. **Peronospora lamii** A. Braun.
*Lamium amplexicaule.** Virginia.

219. **Peronospora myosotidis** De By.
Myosotis verna. Michigan.

220. **Peronospora obovata** Bon.
Spergula arvensis. Maine

221. **Peronospora parasitica** (P.) Tul.
a. Dentaria laciniata. District of Columbia, Maryland.
b. Lepidium virginicum. New Jersey.

222. **Peronospora potentillæ** De By.
Potentilla norvegica. Maryland.

223. **Peronospora rubi** Rabh.
a. Rubus sp. Maryland.
b. Rubus canadensis. Maryland.

224. **Peronospora rumicis** Cda.
Polygonum dumetorum var. *scandems.* Indiana.

225. **Peronospora sordida** Berk.
Scrophularia nodosa. Illinois.

226. **Peronospora viciæ** (B.) De By.
Vicia sativa. Virginia.

227. **Peronospora violæ** De By.
Viola tricolor var. *arvensis.* Illinois.

228. **Phytopthora infestans** (Mont.) De By.
Solanum tuberosum. New Jersey, New York, Vermont.

229. **Plasmopara australis** (Speg.) Swingle.
Sicyos angulatus. Indiana.

230. **Plasmopara cubensis** (B. & C.) Humph.
a. Cucumis sp. Texas.
b. Cucumis sativus. Maryland.

231. **Plasmopara entospora** (R. & C.) Schröt.
Aster novæ-angliæ. Maryland.

232. **Plasmopara geranii** (Pk.) Berl. & De Toni.
a. Geranium carolinianum. Indiana, Missouri, New Jersey.
b. Geranium maculatum. District of Columbia.

233. **Plasmopara halstedii** (Farl.) Berl. & De Toni.
a. Bidens connata. Indiana.
b. Bidens frondosa. Indiana.

234. **Plasmopara obducens** Schröt.
Impatiens sp. Michigan.

235. **Plasmopara pygmæa** (Ung.) Schröt.
Anemone dichotoma. Michigan.

236. **Plasmopara ribicola** Schröt.
Ribes divaricatum. Washington.

237. **Plasmopara viburni** Pk.
Viburnum opulus. Maryland.

238. **Plasmopara viticola** (B. & C.) Berl. & De Toni.
a. Vitis sp. Illinois, Indiana, Massachusetts, Ohio.
b. Vitis sp., cult. var. *Mœnch.* Mississippi.
c. Vitis æstivalis. Illinois.
d. Vitis cordifolia. Indiana.

239. **Sclerospora graminicola** (Sacc.) Schröt.
a. Setaria italica. Michigan.
b. Setaria viridis. Iowa.

240. **Synchytrium decipiens** Farl.
a. Amphicarpæa sp. Minnesota.
b. Amphicarpæa monoica. Indiana.
c. Apios tuberosa. Missouri.

241. **Synchytrium papillatum** Farl.
Erodium cicutarium. California.

242. **Synchytrium pluriannulatum** (Hark.) Farl.
Sanicula marylandica. Michigan.

PYRENOMYCETEÆ.

243. **Asterina inquinans** Ell. & Ever.
Sabal adansonii. Mississippi.

244. **Asterina pelliculosa** Berk.
Ilex lucida. Florida.

245. **Claviceps purpurea** (Fr.) Tul.
a. Agropyrum sp. South Dakota.
b. Elymus virginicus. Illinois.
c. Phalaris arundinacea. New York.
d. Spartina stricta. California.

246. **Didymella culmigena** Sacc.
Muhlenbergia sp. Mississippi.

247. **Epichloe typhina** (P.) Tul.
Glyceria nervata. Missouri.

248. **Erysiphe cichoracearum** DC.
a. Achillea millefolium. Montana.

248. **Erysiphe cichoracearum** DC.—Continued.
- *b. Actinomeris squarrosa.* Illinois, Indiana, Maryland.
- c. *Ambrosia artemisiæfolia.* Indiana.
- d. *Ambrosia trifida.* Indiana.
- e. *Artemisia ludoviciana.* Montana.
- f. *Aster* sp. District of Columbia, Ohio.
- g. *Aster communis.* Montana.
- h. *Aster cordifolius.* Indiana.
- i. *Aster longifolius.* Montana.
- j. *Aster paniculatus.* Indiana.
- k. *Aster puniceus.* Indiana.
- l. *Bigelovia graveolens* var. *albicaulis.* Montana.
- m. *Cnicus altissimus.* Indiana.
- n. *Eupatorium purpureum.* Indiana.
- o. *Helianthus decapetalus.* Indiana.
- p. *Helianthus tuberosus.* Indiana.
- q. *Helianthus tuberosus* var. *subcanescens.* Indiana.
- r. *Parietaria pennsylvanica.* Indiana.
- s. *Phlox* sp. District of Columbia.
- t. *Phlox paniculata.* Indiana.
- u. *Solidago canadensis.* Indiana.
- v. *Verbena hastata.* Illinois.
- w. *Verbena stricta.* Illinois, Indiana.
- x. *Vernonia fasciculata.* Illinois.
- y. *Vernonia noveboracensis.* Indiana.
- z. *Xanthium strumarium.** District of Columbia, Indiana, Maryland, Missouri.

249. **Erysiphe communis** (Wallr.) Fr.
- a. *Amphicarpæa monoica.* Illinois, Indiana.
- b. *Apios tuberosa.* Indiana.
- c. *Clematis virginiana.* Indiana.

249. **Erysiphe communis** (Wallr.) Fr.—Continued.
- d. *Cuphæa viscoscissima.* Maryland.
- e. *Geranium maculatum.* Indiana.
- f. *Lupinus perennis.* Illinois, Michigan.
- g. *Ranunculus abortivus.* Indiana.
- h. *Thermopsis montana.* Colorado.

250. **Erysiphe galeopsidis** DC.
- a. *Stachys aspera.* Indiana.
- b. *Stachys ciliata* var. *pubens.* Washington.

251. **Erysiphe graminis** DC.
- a. *Agropyrum* sp. Montana.
- b. *Agropyrum glaucum.* Montana.
- c. *Poa tenuifolia.* Montana.

252. **Erysiphe trina** Hark.
Quercus agrifolia. California.

253. **Gnomonia ulmea** Thüm.
Ulmus americana. Canada.

254. **Gnomoniella coryli** (Batsch.) Sacc.
Corylus rostrata. Washington.

255. **Gnomoniella fimbriata** (P.) Sacc.
Carpinus caroliniana. West Virginia.

256. **Hypomyces lactifluorum** (Schw.) Tul.
Lactarius sp. New Jersey.

257. **Læstadia bidwellii** (Ell.) Viala & Ravaz.
- a. *Ampelopsis quinquefolia.* District of Columbia, Illinois.
- b. *Vitis* sp. District of Columbia, Illinois, Maryland, North Carolina, Ohio.
- c. *Vitis cordifolia.* Illinois, Indiana.
- d. *Vitis vinifera* var. *Mission.* Texas.

258. **Læstadia illicicola** Tracy & Earle.
*Illicium floridanum.** Mississippi.

259. **Lembosia angustiformis** Tracy & Earle.
Ilex coriacea. Mississippi.

260. **Leptosphæria obtusispora** Speg.
Yucca sp. Mississippi.

261. **Meliola cameliæ** (Catt.) Sacc.
Citrus aurantium. Florida.

262. **Meliola palmicola** Wint.
Sabal serrulata. Florida.

263. **Microsphæra alni** (DC.) Wint.
- *a. Alnus serrulata.* Maryland.
- *b. Carya sulcata.* Indiana.
- *c. Castanea sativa.* West Virginia.
- *d. Ceanothus americanus.* Illinois, New York.
- *e. Corylus americana.* Illinois.
- *f. Fagus ferruginea.* Indiana, New York.
- *g. Juglans nigra.* Indiana.
- *h. Lonicera oblongifolia.* Ohio.
- *i. Lonicera perfoliata.* Iowa.
- *j. Platanus occidentalis.* District of Columbia, Indiana.
- *k. Virbunum dentatum.* Indiana.
- *l. Virbunum lentago.* Iowa.
- *m. Virburnum prunifolium.* Indiana.

264. **Microsphæra diffusa** C. & P.
- *a. Desmodium* sp. District of Columbia, Illinois.
- *b. Desmodium canadense.* Illinois, Iowa.
- *c. Desmodium canescens.* Maryland.
- *d. Lespedeza capitata* Illinois.

265. **Microsphæra elevata** Burrill.
Catalpa sp. District of Columbia.

266. **Microsphæra erineophila** Pk.
- *a. Fagus* sp. District of Columbia.
- *b. Fagus ferruginea.* District of Columbia, Illinois.

267. **Microsphæra euphorbiæ** B. & C.
Euphorbia corollata. Illinois, Maryland.

268. **Microsphæra grossulariæ** Lév.
- *a. Sambucus* sp. Ohio.
- *b. Sambucus canadensis.* New York.

269. **Microsphæra quercina** (S.) Burrill.
- *a. Quercus* sp. Iowa, Michigan, West Virginia.
- *b. Quercus bicolor.*
- *c. Quercus bicolor × macrocarpa.* Indiana.
- *d. Quercus bicolor×michauxii.* Indiana.
- *e. Quercus coccinea.* District of Columbia, Virginia.
- *f. Quercus lyrata.* Indiana.
- *g. Quercus macrocarpa.* Indiana.
- *h. Quercus palustris.* Illinois.
- *i. Quercus prinoides.* Kansas.
- *j. Quercus prinus.* Indiana.
- *k. Quercus rubra.* Illinois, Indiana.

270. **Microsphæra ravenelii** Berk.
- *a. Gleditschia triacanthos.* Indiana, Mississippi.
- *b. Vicia americana,* var. *linearis.* Montana.

271. **Microsphæra russellii** Clint.
Oxalis corniculata var. *stricta.* Illinois.

272. **Microsphæra semitosta** B. & C.
Cephalanthus occidentalis. Indiana.

273. **Microsphæra symphoricarpi** Howe.
- *a. Symphoricarpus* sp. Missouri.
- *b. Symphoricarpus vulgaris.* Missouri.

274. **Microsphæra syringæ** (S.) Magnus.
Syringa vulgaris. District of Columbia, Illinois, Indiana.

275. **Microsphæra vaccinii** C. & P.
- *a. Vaccinium* sp. District of Columbia.
- *b. Vaccinium canadense.* Illinois.

276. **Montagnella heliopisdis** (S.) Sacc.
Heliopsis ? hirsuta. Mississippi.

277. **Ophiobolus anguillides** (Cke.) Sacc.
Ambrosia artemisiæfolia. Mississippi.

278. **Parodiella perisporioides** (B. & C.) Speg.
Rhynchosia tomentosa var. *erecta.* Mississippi.

279. **Phyllachora flabella** (S.) Thüm.
Pteris aquilina. West Virginia.

280. **Phyllachora graminis** (P.) Fckl.
- *a. Andropogon furcatus.* Illinois.
- *b. Distichlis maritima.* New Mexico.
- *c. Elymus* sp. Illinois.
- *d. Elymus canadensis.* Indiana, West Virginia.
- *e. Elymus virginicus.* Virginia.
- *f. Muhlenbergia mexicana.* Indiana, Michigan.
- *g. Sporobolus cuspidatus.* Minnesota.
- *h. Sporobolus depauperatus.* Montana.

281. **Phyllactinia suffulta** (Reb.) Sacc.
- *a. Alnus rubra.* Washington.
- *b. Carpinus caroliniana.* Indiana.
- *c. Celastrus scandens.* Indiana.
- *d. Cephalanthus occidentalis.* Indiana.
- *e. Cornus nuttallii.** Washington.
- *f. Cornus stolonifera.* Montana, New York.
- *g. Corylus americana.* Illinois, Indiana.
- *h. Cratægus coccinea.* New York.
- *i. Cratægus tomentosa.* Illinois.
- *j. Fraxinus* sp. Illinois.
- *k. Fraxinus americana.* Indiana.
- *l. Fraxinus pubescens.* Indiana, Michigan.

281. **Phyllactinia suffulta** (Reb.) Sacc.—Continued.
- *m. Fraxinus quadrangulata.** Indiana.
- *n. Fraxinus sambucifolia.* Indiana, Michigan.
- *o. Liriodendron tulipifera.* Indiana.
- *p. Ostrya virginica.* Indiana, Illinois.
- *q. Quercus coccinea.* Indiana.
- *r. Quercus palustris.* Indiana.
- *s. Vaccinium stamineum.* West Virginia.

282. **Physalospora arthuriana** Sacc.
Baccharis sp. Mississippi.

283. **Physalospora aurantia** Ell. & Ever.
Astragalus pectinatus. Montana.

284. **Plowrightia morbosa** (S.) Sacc.
- *a. Prunus* sp. Maryland, West Virginia.
- *b. Prunus americana.* Maryland.

285. **Plowrightia symphoricarpi** Ell. & Ever.
Symphoricarpus occidentalis. Montana.

286. **Podosphæra biuncinata** C. & P.
Hamamelis virginiana. Illinois.

287. **Podosphæra oxyacanthæ** (DC.) De By.
- *a. Cratægus coccinea.* Michigan.
- *b. Cratægus crus-galli.* Indiana.
- *c. Cratægus spathulata.** Indiana.
- *d. Cydonia vulgaris.* Indiana.
- *e. Prunus americana.* Indiana.
- *f. Prunus cerasus.* Indiana, New York.

288. **Scorias spongiosa** (S.) Fr.
Alnus sp. Maryland.

289. **Sphærella andromedæ** Tracy & Earle.
Andromeda nitida. Mississippi.

290. **Sphærella annulata** Cke.
Magnolia glauca. Mississippi.

291. **Sphærella fragariæ** (Tul.) Sacc.
a. Fragaria sp. District of Columbia, Indiana.
*b. Fragaria elatior.** Indiana.

292. **Sphærella fraxinicola** (S.) Cke.
Fraxinus americana. Indiana.

293. **Sphærella quadrangulata** Ell. & Ever.
*Fraxinus quadrangulata.** Missouri.

294. **Sphærotheca castagnei** Lév.
a. Bidens chrysanthemoides. Indiana.
b. Bidens connata. Indiana.
c. Bidens frondosa. Illinois, Indiana.
d. Brunella vulgaris. Indiana.
e. Erechtites hieracifolia. Indiana.
f. Gerardia sp. District of Columbia.
g. Pedicularis canadensis. Michigan.
*h. Pedicularis lanceolata.** Indiana.
i. Veronica virginica. Illinois.

295. **Sphærotheca humuli** (DC.) Burrill.
a. Agrimonia eupatoria. Indiana.
b. Geum album. Indiana.
c. Gilia linearis. Montana, North Dakota.

296. **Sphærotheca lanestris** Hark.
Quercus prinus. Mississippi.

297. **Sphærotheca mors-uvæ** (S.) B. & C.
a. Ribes sp. New York.
b. Ribes floridum. Nebraska.

298. **Sphærotheca pannosa** (Wallr.) Lév.
a. Rosa lucida. Indiana.
*b. Rubus spectabilis.** Washington.

299. **Sphærotheca phytoptophila** Kell. & Swingle.
a. Celtis occidentalis. Kansas, Missouri.

300. **Uncinula circinata** C. & P.
a. Acer rubrum. Indiana.
b. Acer saccharinum. Indiana.
c. Acer saccharinum var. *nigrum.* Indiana.

301. **Uncinula clintonii** Pk.
Tilia americana. Illinois, Indiana, Michigan.

302. **Uncinula flexuosa** Pk.
Æsculus glabra. Indiana.

303. **Uncinula geniculata** Gerard.
Morus rubra. Indiana, Kansas.

304. **Uncinula macrospora** Pk.
a. Ulmus americana. Iowa, Mississippi.
b. Ulmus fulva. Indiana.

305. **Uncinula necator** (S.) Burrill.
a. Ampelopsis quinquefolia. District of Columbia, Indiana.
b. Vitis sp. (cult.). District of Columbia, Illinois, Indiana, Maine.
c. Vitis vinifera. California.

306. **Uncinula parvula** C. & P.
Celtis occidentalis. Illinois, Indiana.

307. **Uncinula polychæta** (B. & C.) Tracy & Gall.
*Celtis mississippiensis.** Mississippi.

308. **Uncinula salicis** (DC.) Wint.
a. Populus tremuloides. Iowa, Montana.
b. Salix sp. Illinois, Massachusetts, Michigan, Minnesota.
c. Salix caprea var. *pendula.* New York.
d. Salix flavescens. Washington.
e. Salix flavescens var. *scouleriana.* Montana.
f. Salix nigra. Indiana.
g. Salix sericea. Indiana.

309. **Thielavia basicola** Zopf.
Viola sp. Maryland.

310. **Trabutia quercina** (Fr. & Rud.) Sacc. & Roum.
Quercus virens. Mississippi.

311. **Valsa nivea** (Hoffm.) Fr.
Populus tremuloides. Montana.

312. **Winteria lobata** Tracy & Earle.
Ilex lucida. Mississippi.

DISCOMYCETEÆ.

313. **Dermatea carnea** (Cke. & Ell.)
Unrecognized bark. Maryland.

314. **Exoascus deformans** (Berk.) Fckl.
Prunus persica. Georgia, New Jersey.

315. **Niptera ellisii** Rehm.
*Ammophila longifolia.** Montana.

316. **Pseudopeziza trifolii** Fckl.
Trifolium pratense. Washington.

317. **Rhytisma acerinum** (P.) Fr.
a. Acer dasycarpum. Illinois, New Jersey, Virginia, West Virginia.
b. Acer rubrum. West Virginia.

318. **Rhytisma andromedæ** (P.) Fr.
Andromeda polifolia. Michigan.

319. **Rhytisma punctatum** (P.) Fr.
a. Acer sp. West Virginia.
b. Acer macrophyllum. Washington.

320. **Rhytisma solidaginis** Schw.
Solidago lanceolata. Vermont.

321. **Rhytisma vaccinii** Fr.
Vaccinium sp. West Virginia.

322. **Stictis arundinacea** Pers.
Andropogon sp. Mississippi.

323. **Taphrina aurea** (P.) Fr.
Populus balsamifera. Iowa.

324. **Taphrina cærulescens** (Mont. & Desm.) Tul.
a. Quercus sp. Florida, Georgia.
b. Quercus nigra. Georgia.
c. Quercus tinctoria. Massachusetts.

325. **Taphrina ulmi** (Fckl.) Johans.
*Ulmus campestris.** Texas.

326. **Taphrina virginica** Sadeb. & Seymour.
Ostrya virginica. Massachusetts.

SPHÆROPSIDEÆ.

327. **Actinonema rosæ** (Lib.) Fr.
Rosa sp. District of Columbia, Missouri, New Jersey.

328. **Ascochyta pauloowniæ** Sacc. & Brun.
Paulownia imperialis. District of Columbia.

329. **Asteroma liriodendri** Cke.
Liriodendron tulipifera. District of Columbia.

330. **Cicinnobolus cesatii** De By.
a. Aster shortii. Indiana.
b. Hydrophyllum virginicum. Indiana.
c. Rudbeckia triloba. Indiana.
d. Solidago arguta. Indiana.
e. Solidago canadensis var. *procera.* Indiana.
f. Solidago latifolia. Indiana.
g. Taraxacum officinale. Indiana.

331. **Coniothyrium concentricum** (Desm.) Sacc.
a. Yucca sp. North Carolina.
b. Yucca angustifolia. District of Columbia, Missouri.

332. **Coniothyrium diplodiella** (Speg.) Sacc.
Vitis sp. var. *nigra.* South Carolina.

333. **Darluca filum** (Biv.) Cast.
a. Calamintha clinopodium. West Virginia.
b. Carex sp. Indiana.
c. Potentilla canadensis. Ohio.
d. Salix sp. Maryland, West Virginia.

334. **Diplodia hesperidica** Speg.
Citrus aurantium. Mississippi.

335. **Discosia rugulosa** B. & C.
Carya alba. Illinois.

336. **Entomosporium maculatum** Lév.
a. Cydonia sp. Delaware, New York.
b. Cydonia vulgaris. Michigan, New Jersey.
c. Pirus communis. Georgia, New York, Texas.
d. Pirus malus. New York.
*e. Pirus sinensis.** New Jersey.

337. **Hendersonia mali** Thüm.
Pirus malus. Illinois.

338. **Kellermania yuccægena** Ell. & Ever.
Yucca sp. Mississippi.

339. **Melasmia gleditschiæ** Ell. & Ever.
Gleditschia triacanthos. Kansas.

340. **Phleospora aceris** (Lib.) Sacc.
a. Acer dasycarpum. Illinois, Kansas, Michigan, Minnesota, Missouri.
b. Acer rubrum. Indiana.

341. **Phleospora anemones** Ell. & Kell.
Anemone virginiana. Massachusetts.

342. **Phleospora mori** (Lév.) Sacc.
Morus rubra. District of Columbia.

343. **Phleospora ulmi** (Fr.) Wallr.
a. Ulmus sp. Michigan.
b. Ulmus americana. District of Columbia, Illinois.
c. Ulmus fulva. District of Columbia, Illinois, Indiana, Kansas.

344. **Phoma maculans** (B. & C.) Sacc.
Bumelia sp. Mississippi.

Phoma uvicola B. & C.
See **Læstadia bidwellii** (Ell.) Viala & Ravaz.

345. **Phoma virginiana** Ell. & Halsted.
Prunus virginiana. Illinois.

346. **Phyllosticta acericola** C. & E.
a. Acer dasycarpum. Missouri, New Jersey.
*b. Acer platanoides** New Jersey.
c. Acer rubrum. Maine, Virginia.

347. **Phyllosticta æsculi** Ell. & Mart.
a. Æsculus sp. District of Columbia.
b. Æsculus glabra. Missouri.
c. Æsculus hippocastanum. District of Columbia, Maryland.

Phyllosticta ampelopsidis Ell. & Mart.
See **Læstadia bidwellii** (Ell.) Viala & Ravaz.

348. **Phyllosticta asiminæ** Ell. & Kell.
Asimina triloba. District of Columbia, Indiana, Maryland, Missouri.

349. **Phyllosticta catalpæ** Ell. & Mart.
Catalpa bignonioides. District of Columbia.

350. **Phyllosticta celtidis** Ell. & Kell.
Celtis occidentalis. Indiana.

351. **Phyllosticta circumscissa** Cke.
a. Prunus americana. Illinois.
b. Prunus persica. Washington.

352. **Phyllosticta cornicola** (DC.) Rabh.
Cornus florida. District of Columbia.

353. **Phyllosticta destruens** Desm.
Prunus americana. Kansas.

354. **Phyllosticta eriobotryæ** Thüm.
Photinia japonica. Louisiana.

355. **Phyllosticta eupatorina** Thüm.
Eupatorium purpureum. Illinois.

356. **Phyllosticta gossypina** Ell. & Mart.
Gossypium herbaceum. North Carolina.

357. **Phyllosticta liriodendrica** Sacc.
Liriodendron tulipifera. West Virginia.

358. **Phyllosticta minutissima** Ell. & Ever.
Acer glabrum. Nebraska.

359. **Phyllosticta paulowniæ** Sacc.
Paulownia imperialis. District of Columbia.

360. **Phyllosticta pirina** Sacc.
Pirus malus. District of Columbia, Maryland, Missouri, New Jersey, West Virginia.

361. **Phyllosticta sassafras** Cke.
Sassafras officinale. Illinois, Missouri.

362. **Phyllosticta sphæropsoidea** Ell. & Ever.
Æsculus hippocastanum. New Jersey.

363. **Piggotia fraxini** B. & C.
- a. *Fraxinus* sp. Missouri.
- b. *Fraxinus americana.* Mississippi.

364. **Septoria acicola** (Thüm.) Sacc.
Pinus sp. Missouri.

365. **Septoria æsculi** (Lib.) West.
Æsculus glabra. Indiana.

366. **Septoria agrimoniæ-eupatoriæ** Bomm. & Rouss.
Agrimonia eupatoria. Missouri.

367. **Septoria ampelina** B. & C.
- a. *Vitis* sp. var. *Duchess.* Kansas.
- b. *Vitis* sp. var. *Herbert.* Kansas.

368. **Septoria asclepiadicola** Ell. & Ever.
Asclepias incarnata. Indiana.

369. **Septoria atropurpurea** Pk.
Aster cordifolius. District of Columbia.

370. **Septoria aurea** Ell. & Ever.
Ribes aureum. Kansas.

371. **Septoria calcaliæ** Ell. & Kell.
Cacalia atriplicifolia. Missouri.

372. **Septoria campanulæ** (Lév.) Sacc.
Campanula americana. Iowa.

373. **Septoria cannabina** West.
Cannabis sativa. Illinois.

374. **Septoria conspicua** Ell. & Mart.
Steironema ciliatum. Indiana.

375. **Septoria cornicola** Desm.
Cornus florida. District of Columbia.

376. **Septoria erigerontia** Pk.
Erigeron annuus. Illinois.

377. **Septoria graminum** Desm.
- a. *Triticum vulgare.* Maryland.
- b. *Triticum vulgare* var. *Zimmerman.* Kansas.

378. **Septoria kalmiæcola** (S.) B. & C.
Kalmia latifolia. District of Columbia.

379. **Septoria lactucæ** Pass.
Lactuca sativa. Indiana.

380. **Septoria lobeliæ** Pk.
Lobelia syphilitica. Illinois.

381. **Septoria mimuli** Ell. & Kell.
Mimulus alatus. Illinois.

382. **Septoria nolitangeris** Gerard.
Impatiens sp. Massachusetts.

383. **Septoria œnotheræ** West.
- a. *Oenothera biennis.* District of Columbia, Illinois, Iowa, Maryland, Missouri.
- b. *Oenothera sinuata.* Mississippi.

384. **Septoria phlogis** Sacc. & Speg.
Phlox perennis. Canada.

385. **Septoria physostegiæ** Ell. & Ever.
Physostegia virginica. Illinois.

386. **Septoria pileæ** Thüm.
Pilea pumila. Iowa.

387. **Septoria polygonorum** Desm.
Polygonum pennsylvanicum. Illinois.

388. **Septoria psilostega** Ell. & Mart.
Galium circæzans. Indiana.

389. **Septoria rhoina** B. & C.
Rhus typhina. Iowa.

390. **Septoria rubi** West.
   a. *Rubus* sp. New Jersey.
   b. *Rubus canadensis.* Maryland, New Jersey.
   c. *Rubus villosus.* Texas.

391. **Septoria saccharina** Ell. & Ever.
   Acer saccharinum. Vermont.

392. **Septoria sambucina** Pk.
   Sambucus canadensis. Michigan.

393. **Septoria scrophulariæ** Pk.
   Scrophularia nodosa. Minnesota, Missouri.

394. **Septoria smilacina** Ell. & Mart.
   *Smilacina racemosa.** Minnesota.

395. **Septoria speculariæ** B. & C.
   Specularia leptocarpa. Montana.

396. **Septoria trillii** Pk.
   *Trillium sessile.** Missouri.

397. **Septoria verbenæ** Rob.
   Verbena hastata. Illinois.

398. **Septoria violæ** West.
   a. *Viola* sp. New Jersey.
   b. *Viola blanda.* New Jersey.

399. **Septoria wilsoni** Clinton.
   Chelone glabra. Ohio.

400. **Vermicularia albomaculata** Schw.
   Liriodendron tulipifera. District of Columbia.

401. **Vermicularia stachydis** Tracy & Earle.
   *Stachys affinis.** Missouri.

MELANCONIEÆ.

402. **Colletotrichum glœosporioides** Penzig var. *hederæ* Passer.
   Hedera helix. District of Columbia.

403. **Colletotrichum lagenarum** Ell. & Halsted.
   Cucumis sativus. New Jersey.

404. **Colletotrichum lineola** Cda.
   Sorghum vulgare. Missouri.

405. **Colletotrichum pisi** Pat.
   Pisum sativum. Ecuador.

406. **Cylindrosporium clematidis**, Ell. & Ever. var. **jackmanni** Ell. & Ever.
   *Clematis jackmanni.** New York.

407. **Cylindrosporium fraxini** (Ell. & Kell.) Ell. & Ever.
   a. *Fraxinus americana.* Maryland.
   b. *Fraxinus viridis.* Maryland.

408. **Cylindrosporium humuli** Ell. & Ever.
   Humulus lupulus. Michigan.

409. **Cylindrosporium padi** Karst.
   a. *Prunus* sp. Maryland.
   b. *Prunus cerasus.* Nebraska.
   c. *Prunus domestica.* Michigan.
   d. *Prunus domestica* var. *Farleigh damson.* New York.
   e. *Prunus domestica* var. *Fellenberg.* New York.
   f. *Prunus domestica* var. *Field plum.* New York.
   g. *Prunus serotina.* West Virginia.
   h. *Prunus virginiana.* Michigan.

410. **Cylindrosporium rubi** Ell. & Morg.
   Rubus sp. Missouri.

411. **Glœosporium ampelophagum** (Pass.) Sacc.
   Vitis sp. Maryland, New York, Virginia.

412. **Glœosporium apocyni** (Pk.) Ell. & Ever.
   Apocynum cannabinum. Indiana.

413. **Glœosporium betularum** Ell. & Mart.
   Betula nigra. District of Columbia.

414. **Glœosporium canadense** Ell. & Ever.
   Quercus alba. Canada, Connecticut.

415. **Glœosporium celtidis** Ell. & Ever.
   Celtis occidentalis. Canada.

416. Glœosporium equiseti Ell. & Ever.
Equisetum sp. Illinois.

417. Glœosporium nervisequum (Fckl.) Sacc.
Platanus occidentalis. District of Columbia, Missouri.

418. Glœosporium ochroleucum Ell. & Ever.
Castanea sativa var. _americana._ Virginia.

419. Glœosporium phegopteridis Frank.
Aspidium thelypteris. Massachusetts.

420. Glœosporium septorioides Sacc.
Quercus sp. Indiana.

421. Glœosporium venetum Speg.
a. Rubus sp. Missouri.
_b. Rubus idæus_* var. _Gregg._ Ohio.
c. Rubus idæus var _Shaffer._ New York.
d. Rubus idæus var. _Souhegan._ Ohio.

422. Marsonia juglandis (Lib.) Sacc.
a. Juglans cinerea. Illinois, Ohio.
b. Juglans nigra. Michigan.

423. Marsonia martini Sacc. & Ell.
a. Quercus sp. Illinois.
b. Quercus alba. District of Columbia, Indiana.
c. Quercus bicolor. Indiana.
d. Quercus prinus. Indiana.
e. Quercus rubra. Indiana.

424. Marsonia potentillæ (Desm.) Fisch.
Fragaria sp. Montana.

425. Marsonia quercus Pk.
a. Quercus alba. Missouri.
b. Quercus prinus. Missouri.

426. Pestalozzia funerea Desm.
Smilax laurifolia. Mississippi.

HYPHOMYCETEÆ.

427. Alternaria solani (E. & M.) Sor.
Solanum tuberosum. Missouri, Vermont.

428. Arthrobotrys rosea Massee.
Avena sativa. District of Columbia.

429. Botrytis hypophylla Ell. & Kell.
Polygonum hydropiper. Missouri.

430. Botrytis vulgaris Fr.
Lactuca sativa. District of Columbia.

431. Ceratophorum uncinatum (C. & P.) Sacc.
a. Carya amara. Kansas.
b. Quercus macrocarpa. Indiana.

432. Cercospora acalyphæ Pk.
Acalypha virginica. North Carolina.

433. Cercospora ampelopsidis Pk.
Ampelopsis quinquefolia. Indiana, Minnesota, West Virginia.

434. Cercospora apii Fres.
a. Apium graveolens. Maryland, Michigan, Missouri.
b. Daucus carota. Maryland, New Jersey.

435. Cercospora apii Fres. var. _pastinacæ_ Farl.
Pastinaca sativa. New Jersey.

436. Cercospora atromaculans Ell. & Ever.
Aralia spinosa. West Virginia.

437. Cercospora beticola Sacc.
Beta vulgaris. Illinois, Michigan.

438. Cercospora brunkii Ell. & Gal.
a. Geranium sp. Texas.
_b. Pelargonium peltatum._* Texas.

439. Cercospora canescens Ell. & Mart.
a. Phaseolus sp. Illinois.
b. Phaseolus lunatus var. _Dreer's Improved._ Kansas.
c. Phaseolus lunatus var. _New Challenge._ Kansas.

440. Cercospora caulicola Wint.
Asparagus officinalis. Maryland.

441. **Cercospora caulophylli** Pk.
Anemonella thalictroides. Missouri.

442. **Cercospora cercidicola** Ell.
Cercis canadensis. District of Columbia, Illinois, Indiana.

443. **Cercospora circumscissa** Sacc.
  - *a. Prunus* sp. District of Columbia, Illinois, Texas.
  - *b. Prunus cerasus.* Ohio, New Jersey.
  - *c. Prunus serotina.* Illinois, West Virginia.

444. **Cercospora clavata** (Ger.) Pk.
  - *a. Asclepias cornuti.* Michigan.
  - *b. Asclepias incarnata.* Illinois, Indiana, West Virginia.

445. **Cercospora coffeicola** B. & C.
*Coffea arabica.** Hawaii.

446. **Cercospora desmodii** Ell. & Kell.
  - *a. Desmodium acuminatum.* Illinois.
  - *b. Desmodium rotundifolium.* District of Columbia.

447. **Cercospora diodiæ** Cke.
Diodia teres. District of Columbia.

448. **Cercospora dubia** (Riess) Wint.
  - *a. Chenopodium album.* District of Columbia, Illinois, Indiana.
  - *b. Spinacea oleracea.* Missouri.

449. **Cercospora effusa** (B. & C.) Ell. & Ever.
Lobelia syphilitica. West Virginia.

450. **Cercospora erythrogena** Atk.
Rhexia mariana. Mississippi.

451. **Cercospora evonymi** Ell.
Evonymus atropurpureus. Illinois.

452. **Cercospora ferruginea** Fckl.
Ambrosia trifida. Illinois.

453. **Cercospora flagellaris** Ell. & Mart.
Phytolacca decandra. Illinois.

454. **Cercospora flexuosa** Tracy & Earle.
Diospyros virginiana. Mississippi.

455. **Cercospora fusco-virens** Sacc.
Passiflora sp. Missouri.

456. **Cercospora granuliformis** Ell. & Hol.
Viola var. *cucullata.* Indiana.

457. **Cercospora hydropiperis** (Thüm.) Speg.
Polygonum hydropiper. Illinois, Indiana.

458. **Cercospora ilicis** Ellis.
Ilex glabra. Mississippi.

459. **Cercospora ipomœæ** Wint.
Ipomœa pandurata. Illinois.

460. **Cercospora lippiæ** Ell. & Ever.
*Lippia lanceolata.** Illinois.

461. **Cercospora liriodendri** Ell. & Hark.
Liriodendron tulipifera. Mississippi.

462. **Cercospora maritima** Tracy & Earle.
*Croton maritimus.** Mississippi.

463. **Cercospora microsora** Sacc.
Tilia americana. Illinois, Michigan.

464. **Cercospora mississippiensis** Tracy & Earle.
  - *a. Smilax* sp. Mississippi.
  - *b. Smilax bona-nox.* Mississippi.

465. **Cercospora moricola** Cke.
Morus rubra. Mississippi.

466. **Cercospora nigricans** Cke.
Cassia marylandica. Missouri.

467. **Cercospora nymphæacea** C. & E.
  - *a. Nymphæa* sp. Ohio.
  - *b. Nymphæa odorata?* Illinois.

468. **Cercospora oculata** Ell. & Kell.
Vernonia noveboracensis. Indiana.

469. **Cercospora olivacea** (B. & Rav.) Wint.
Gleditschia triacanthos. Illinois, Iowa.

470. **Cercospora oxybaphi** Ell. & Halsted.
Oxybaphus nyctagineus. Illinois.

471. **Cercospora personata** (B. & C.) Ell. & Ever.
Arachis hypogea. Mississippi.

472. **Cercospora pteleæ** Wint.
Ptelea trifoliata. Indiana.

473. **Cercospora pustula** Cke.
Ampelopsis quinquefolia. Virginia.

474. **Cercospora racemosa** Ell. & Mart.
- *a. Ambrosia trifida.* District of Columbia.
- *b. Teucrium canadense.* Indiana, Michigan.

475. **Cercospora resedæ** Fckl.
Reseda odorata. Illinois.

476. **Cercospora rhoina** C. & E.
- *a. Rhus* sp. Mississippi.
- *b. Rhus aromatica.* Missouri.
- *c. Rhus copallina.* Mississippi.
- *d. Rhus glabra.* District of Columbia, Indiana, Missouri.
- *e. Rhus typhina.* District of Columbia.

477. **Cercospora rosicola** Pass.
- *a. Rosa* sp. District of Columbia, Missouri.
- *b. Rosa setigera.** Indiana.

478. **Cercospora rubi** Sacc.
- *a. Rubus* sp. Missouri.
- *b. Rubus canadensis.* Maryland.
- *c. Rubus villosus.* Illinois.

479. **Cercospora sagittariæ** Ell. & Kell.
Sagittaria variabilis. Illinois, Texas.

480. **Cercospora sanguinariæ** Pk.
Sanguinaria canadensis. Missouri.

481. **Cercospora saururi** Ell. & Ever.
Saururus cernuus. Illinois, Indiana.

482. **Cercospora sedoides** Ell. & Ever.
Penthorum sedoides.

483. **Cercospora simulata** Ell. & Ever.
Cassia marylandica. Indiana, Missouri.

484. **Cercospora smilacis** Thüm.
- *a. Smilax* sp. Missouri.
- *b. Smilax glauca.* West Virginia.

485. **Cercospora sordida** Sacc.
Tecoma radicans. Illinois, Missouri.

486. **Cercospora squalidula** Pk.
- *a. Clematis* sp. North Dakota.
- *b. Clematis ligusticifolia.* Nebraska.

487. **Cercospora teucrii** Ell. & Kell.
Teucrium canadense. Indiana.

488. **Cercospora umbrata** Ell. & Hol.
Bidens frondosa. Michigan.

489. **Cercospora viticola** (Ces.) Sacc.
- *a. Vitis* sp. District of Columbia, North Carolina, Virginia.
- *b. Vitis cordifolia.* Illinois.

490. **Cercosporella cana** (Pass.) Sacc.
Erigeron annuus. District of Columbia, Indiana.

491. **Cercosporella persica** Sacc.
Prunus persica. Maryland.

492. **Cladosporium carpophilum** Thüm.
Prunus persica. Illinois.

493. **Cladosporium fulvum** Cke.
Lycopersicum esculentum. Maryland, New Jersey.

494. **Cladosporium pæoniæ** Pass.
Pæonia officinalis. District of Columbia.

495. **Cladosporium typharum** Desm.
Typha latifolia. Montana.

496. **Didymaria clematidis** Cke. & Hark.
Clematis ligusticifolia. Montana.

497. **Didymaria ungeri** Cda.
*Ranunculus septentrionalis.** Indiana.

498. **Epicoccum neglectum** Desm.
Tripsacum dactyloides. Mississippi.

499. **Fusarium rubi** Wint.
Rubus villosus. Illinois.

500. **Fusicladium dendriticum** (Wallr.) Fckl.
Pirus malus. Indiana, Kansas, Michigan, Missouri, New York.

501. **Fusicladium pirinum** Fckl.
Pirus communis. Michigan.

502. **Glenospora curtisii** Berk. & Desm.
Nyssa sp.

Helminthosporium fragile Sorokin.
See **Thielavia basicola** Zopf.

503. **Helminthosporium gramineum** Rabh.
Hordeum vulgare. Canada.

504. **Helminthosporium inconspicuum** C. & E.
Zea mays. Illinois, New Jersey.

505. **Helminthosporium ravenelii** M. A. Curtis.
Sporobolus indicus. Mexico.

506. **Helminthosporium turcicum** Pass.
Sorghum vulgare. Kansas.

507. **Isariopsis linderæ** (Ell. & Ever.) Sacc.
Diospyros virginiana? West Virginia.

508. **Macrosporium brassicæ** Berk.
Brassica sp. Alabama.

509. **Macrosporium cookei** Sacc.
Datura sp. Maryland.

510. **Macrosporium parasiticum** Thüm.
Allium cepa. New York.

511. **Macrosporium sarcinæforme** Cav.
Trifolium pratense. Kansas.

512. **Microstroma juglandis** (Bér.) Sacc.
a. *Juglans cinerea.* New Jersey.
b. *Juglans nigra.* District of Columbia, Missouri.

513. **Monilia fructigena** Pers.
a. *Prunus* sp. Maryland.
b. *Prunus persica.*

514. **Napicladium arundinaceum** (Cda.) Sacc.
Phragmites communis. Nebraska.

515. **Oidium obductum** Ell. & Lang.
a. *Quercus alba.* Illinois.
b. *Quercus imbricaria.* California.

516. **Ovularia obliqua** (Cke.) Oud.
Rumex crispus. Maryland, New Jersey.

517. **Periconia pycnospora** Fres.
Yucca sp. Florida.

518. **Piricularia grisea** (Cke.) Sacc.
Setaria sp. Nebraska.

519. **Polythrincium trifolii** Kunze.
Trifolium repens. Indiana, Maryland, Massachusetts, New Jersey.

520. **Ramularia areola** Atk.
Gossypium sp. Mississippi.

521. **Ramularia celastri** Ell. & Mart.
Celastrus scandens. Canada.

522. **Ramularia desmodii** Cke.
Desmodium sp. Illinois, Missouri.

523. **Ramularia diervillæ** Pk.
Diervilla trifida. New Hampshire.

524. **Ramularia gibba** Fckl.
Ranunculus repens. Illinois.

525. **Ramularia hamamelidis** Pk.
a. *Hamamelis* sp. West Virginia.
b. *Hamamelis virginica.* Illinois.

526. **Ramularia macrospora** Fres.
Erigeron annuus. New Jersey.

527. **Ramularia parietariæ** Pass.
Parietaria pennsylvanica. Missouri.

528. **Ramularia plantaginis** Ell. & Mart.
Plantago major. Indiana, New Jersey.

529. **Ramularia rudbeckiæ** Pk.
Rudbeckia laciniata. Michigan, West Virginia.

530. **Ramularia rufo-maculans** Pk.
Polygonum acre. Indiana.

Ramularia tulasnei Sacc.
See **Sphærella fragariæ** (Tul.) Sacc.

531. **Ramularia urticæ** Ces.
Urtica gracilis. Illinois.

532. **Ramularia vaccinii** Pk.
Vaccinium pennsylvanicum. District of Columbia.

533. **Ramularia variabilis** Fckl.
Verbascum thapsus. Michigan.

534. **Scolecotrichum graminis** Fckl.
*a. Festuca elatior.** Kansas.
b. Phleum pratense. Indiana.
c. Poa sp. Maryland.
*d. Poa nemoralis.** Indiana.
e. Poa pratensis. Indiana.

535. **Scolecotrichum punctulatum** Tracy & Earle.
Iris pabularia. Mississippi.

536. **Septosporium heterosporum** Ell. & Gal.
Vitis californica. California.

537. **Steirochæte graminicola** (Ces.) Sacc.
Bromus unioloides. Texas.

538. **Stigmina platani** (Fckl.) Sacc.
Platanus occidentalis. Illinois.

539. **Stilbum flavidum** Cke.
*Coffea arabica.** Guatemala.

540. **Tetraploa divergens** Tracy & Earle.
Panicum agrostidiforme. Mississippi.

541. **Tubercularia vulgaris** Tode.
Ficus sp. California.

542. **Ustilaginoidea virens** (Cke.) Tak.
Oryza sativa. Japan.

543. **Volutella dianthi** (Hal.) Atk.
*Dianthus caryophyllus.** District of Columbia.

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN No. 9.
B. T. GALLOWAY, Chief of Bureau.

THE NORTH AMERICAN SPECIES OF SPARTINA.

BY

ELMER D. MERRILL, Assistant Agrostologist,
GRASS AND FORAGE PLANT INVESTIGATIONS.

Issued February 4, 1902.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., November 25, 1901.

Sir: I have the honor to transmit herewith the manuscript of a paper entitled The North American Species of Spartina and to recommend that it be published as Bulletin No. 9 of the Bureau series. The paper was prepared by Mr. Elmer D. Merrill, Assistant Agrostologist, Grass and Forage Plant Investigations, and was submitted by the Agrostologist.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The accompanying technical paper on the genus *Spartina* is based entirely on material from North America, and the recent great increase in the available amount of herbarium material has shown the pressing need for a thorough inquiry into the bibliography, synonymy, and relationships of the several species which comprise the genus.

The various species of *Spartina* are found in saline soils along the coast throughout the tropical and temperate regions of the world, two species are found in alkaline soils of the interior, and one species only is known to thrive in soils free from alkaline or saline properties.

At different times various authors have proposed at least 6 different generic names for the grasses now comprised in *Spartina*, and under the name *Spartina* alone about 36 specific names have been proposed for the dozen or fifteen valid species now known in the world. Of these species, 9 are recognized as growing in North America, and are described in the present paper, one of which and one variety are proposed as new.

F. Lamson-Scribner.
Agrostologist.

Office of the Agrostologist,
Washington, D. C., November 16, 1901.

B. P. I.—11. Agros.—90.

THE NORTH AMERICAN SPECIES OF SPARTINA.

SPARTINA Schreb. Gen. **1**: 43. 1789. (*Trachynotia* Michx. Fl. Bor. Am. **1**: 63. 1803; *Limnetis* Pers. Syn. **1**: 72. 1805; *Ponceletia* Thou. Fl. Trist. d'Acugn. 36. 1811; *Tristania* Poir. in Lam. Encycl. Suppl. **4**: 526. 1816; *Solenachne* Steud. Syn. Pl. Gram. 12. 1854; *Chauvinia* Steud. l. c. 362.)

Spikelets 1-flowered, strongly flattened laterally, sessile, and closely imbricated in two rows along one side of a continuous rachis, forming unilateral spikes which are scattered along a common axis; rachilla articulated below the empty glumes and not produced beyond the floret. Glumes three, the first two empty, keeled, acute, or bristle pointed, unequal, the second usually exceeding the flowering glume. Stamens 3. Styles elongated, filiform. Grain narrow, free within the glume and palea. Coarse perennials, with strong, creeping rootstocks, rigid culms, and long, tough leaves.

Spartina comprises a small but distinct genus of the tribe *Chlorideae* of almost strictly halophytic grasses ranging along the coasts of Europe, Africa, North and South America, and in saline or alkaline soils of the interior, *Spartina cynosuroides* being somewhat exceptional to this rule, as it reaches its greatest development along streams and lakes of fresh water. There are about 12 recognized species in this genus in the world, 9 of which are found in North America, one of which is here proposed as a new species.

Bentham[a] removed *Spartina* from the *Chlorideæ* and placed it in the *Chamaeraphis* group of the *Paniceae* for the reasons that the spikelets contain but a single perfect flower, and that the pedicels are articulated below the empty glumes. Scribner[b] discusses this transfer with the conclusion that *Spartina* should properly be referred to the *Chlorideae*, as its affinities are with this tribe rather than with the *Paniceae*, with the query that as the articulation of the pedicel below the empty glumes forms an exception in certain genera in the *Poaceae* and other tribes, why should not *Spartina* be considered a like exception in the *Chlorideae*. Hackel retains the genus in the *Chlorideae*.

As a genus *Spartina* does not take high rank from an economic standpoint, but as the several species grow in situations where other or better grasses will not thrive it must be considered as possessing a distinct economic value. Several of the species, on account of their strong, creeping rootstocks, are valuable for binding river banks and sea shores subject to wash. *Spartina cynosuroides* annually supplies many thousands of tons of native hay in the middle West, and it has been utilized for making a coarse paper. *Spartina patens* with "black grass" (*Juncus gerardi*) furnishes the bulk of the "salt hay" of the Atlantic coast, and on account of its tough, wiry culms and leaves it is especially adapted for use as packing material for crockery, glassware, etc.

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[a] Notes on the Gramineae, Journ. Linn. Soc. **19**: 50. 1881.

[b] Bull. Torr. Bot. Club, **10**: 85. 1883.

Among the points of particular interest brought out in the present paper are that *Spartina glabra* Muhl., has been wrongly referred to the European *S. stricta*, a species not found in North America, while on the other hand *Spartina versicolor* Fabre, from southern Europe, is doubtless identical with *Spartina juncea* of our Atlantic coast. *Spartina foliosa* Trin., is a valid species, while *Vilfa spartinae* Trin., is identical with *Spartina junciformis* Engelm. & Gray.

On account of many intergrading forms it has been found rather difficult to properly characterize some species in this genus, but we trust that the present paper may serve to clear up some difficult points, at least in synonymy. This article is based entirely on material in the United States National Herbarium, and examination of other herbaria would doubtless extend the range of some of the species here considered.

ANALYTICAL KEY TO THE SPECIES.

1. Leaf-blades plane or nearly so 2
1. Leaf-blades strongly involute 6
2. Second glume very strongly aculeolate-scabrous on the keel and adjacent nerves. 3
2. Second glume glabrous, or if aculeolate-scabrous only so on the keel 5
3. Plants very stout; spikelets 12 to 14 mm. long 4
3. Plants slender; spikelets 6 to 9 mm. long; a Western species .... 6 **S. gracilis.**
4. Spikes very numerous, second glume scarcely awned .... 2 **S. polystachya.**
4. Spikes few, second glume bearing a stout scabrous awn .... 1 **S. cynosuroides.**
5. Inflorescence dense and spike-like; culm leaves numerous, short; a Pacific coast species .... 4 **S. foliosa.**
5. Inflorescence usually somewhat open, the spikes ascending or erect. 3 **S. glabra.**
6. Spikes appressed, forming a long, dense, spike-like inflorescence. 5 **S. junciformis.**
6. Spikes erect or spreading; inflorescence not spike-like 7
7. A stout plant; the leaves sometimes 18 dm. in length .... 9 **S. bakeri.**
7. Plants more slender; leaves not exceeding 8 dm. in length 8
8. Spikes broad; a Western species .... 6 **S. gracilis.**
8. Spikes narrow; Atlantic coast species 9
9. Plant slender, not exceeding 9 dm. in height; leaves spreading, less than 3.5 dm. in length .... 8 **S. patens.**
9. Plant stouter, often 12 dm. high or more; leaves erect or ascending, 2 to 6 dm. long .... 7 **S. juncea.**

1. **SPARTINA CYNOSUROIDES** (Linn.) Willd. Enum. 80. 1809. (*Dactylis cynosuroides* Linn. Sp. Pl. 71. 1753; *Trachynotia cynosuroides* Michx. Fl. Bor. Am. **1**: 64. 1803; *Limnetis cynosuroides* Pers. Syn. **1**: 72. 1805; *Spartina pectinata* Bosc. in Link, Jahrb. **3**: 92. 1820.)

A stout erect perennial 6 to 18 dm. high with unbranched glabrous culms from stout, scaly rootstocks, long tough leaf-blades and 5 to 20 spikes, forming a terminal panicle. Sheaths crowded below; ligule a ring of hairs; leaf-blades 3 to 12 or 18 dm. long, 4 to 14 mm. wide, scabrous on the margins, becoming involute in drying, attenuate into a long slender tip. Spikes 5 to 10 cm. long, often on peduncles, 1 to 2 cm. in length, ascending, racemose along the main axis, which is scabrous on the margins, as are also the secondary axes. Spikelets densely imbricate, 12 to 14 mm. long; empty glumes unequal, strongly aculeolate-scabrous on the rigid keels, the first usually acute, the second long acuminate and more or less awned; flowering glume 7 to 9 mm. long, glabrous, except for the aculeolate-scabrous midnerve which terminates just below the emarginate or 2-toothed apex. Palea thinner in texture and usually somewhat exceeding the glume.

GENERAL DISTRIBUTION: In swamps and along banks of streams and lakes of fresh or brackish water, Nova Scotia to Assiniboia and Washington, south to New Jersey and Indian Territory, August to October.

Type locality: "Habitat in Virginia, Canada, Lusitiana."

Specimens examined.—*New Brunswick:* St. John, J. Fowler, Aug. 17, 1877. *Maine:* Cape Elizabeth, F. Lamson-Scribner, July 27, 1895, also July 26, 1895; Chemo Pond, Bradley, 3 F. P. Briggs, August, 1897. *Massachusetts:* Nantucket, E. N. Vasey, Aug. 22, 1897. *Connecticut:* Bridgeport, E. H. Eames, July 27, 1895. *New York:* Niagara Falls, F. V. Coville, Aug. 21, 1886. *New Jersey:* Deal, A. H. and C. E. Smith; Granton, salt marsh, Wm. M. Van Sickle, July 1, 1894, also July 1, 1895. *Pennsylvania:* Easton, Thos. C. Porter, Sept. 5, 1896; Harrisburg, John K. Small, July 26, 1888; mouth of Tucquan, Lancaster County, A. A. Heller and E. Gertrude Halback, Oct. 1, 1892. *Delaware:* Ellendale, Wm. M. Canby; Wilmington, 260 A. Commons, July 28, 1881, also 259 Commons, Aug. 16, 1877. *Maryland:* Great Falls, Vasey, 1873. *District of Columbia:* Washington, in grass garden, Aug. 5, 1897. *Illinois:* Pierceville, L. M. Umbach, Aug. 22, 1895. *Wisconsin:* Near Grandmother Bull Falls, L. S. Cheney, 1893. *Minnesota:* Courtland, C. A. Ballard, July, 1892. *Assiniboia:* Indian Head, John Macoun, Aug. 15, 1895. *North Dakota:* Dickinson, M. A. Brannon, Aug. 11, 1896. *South Dakota:* Near Grindstone, 749 David Griffiths, Aug. 31, 1897; Black Hills, altitude 4,000 feet, 1103 P. A. Rydberg, July 16, 1892; Huron, 3 David Griffiths, Aug. 25, 1896; Orol Butte, 331 D. Griffiths, July 1, 1897; Brookings, T. A. Williams, August, 1891; Aberdeen, 96 David Griffiths, Sept. 12, 1893, also 116 Griffiths, Sept. 15, 1896; Jamesville, 4 L. A. Bruce, Aug. 3, 1899. *Iowa:* Chariton, 1001 S. H. Mallory, Oct. 2, 1897; Fayette County, 320 B. Fink, July 6, 1894, also 559 Fink, September, 1894; Mount Pleasant, J. H. Mills, 1894. *Nebraska:* Whitman, 1577 P. A. Rydberg, July 29, 1893; Talmage, 10 C. C. Elmore, July 7, 1896; Niobrara River, 2892 Fred Clements, Aug. 18, 1893; North Platte, 2514 P. A. Rydberg, Sept. 5, 1895. *Kansas:* Hutchinson, 5 B. B. Smyth, July 28, 1890; Riley County, 562 J. B. Norton, Oct. 5, 1895; Syracuse, 156 C. H. Thompson, July 28, 1893. *Indian Territory:* Choctaw Agency, J. M. Bigelow, 1853; Pawnee, J. W. Blankinship, Aug. 30, 1895. *Montana:* Madison River, 2283 P. A. Rydberg, July 28, 1895, 523 C. L. Shear, July 28, 1895. *Wyoming:* At G. A. Bell's ranch, altitude 1300 m., 2844 T. A. Williams, Aug. 5, 1897; No Wood Creek, 2846 T. A. Williams, Aug. 5, 1897; no locality, Hayden's U. S. Geological Survey, 1870. *Colorado:* La Salle, 764 C. L. Shear, Sept. 4, 1895; Fort Collins, 558 C. S. Crandall, altitude 1520 m., Aug. 24, 1894. *Idaho:* Thompson, 1611 J. B. Leiberg, altitude 620 m., Aug. 27, 1895; Lake Tesemini, 691 J. H. Sandberg, A. A. Heller, and D. T. McDougal, July 21, 1892. *Washington:* Fish Hook Ferry, 938 J. B. Leiberg, altitude 210 m., Sept. 18, 1894; Snake River, Almota, 2372 C. V. Piper, Sept. 9, 1896. *Oregon:* Snake River, Ballard's Landing, 2221 Wm. C. Cusick, July 8, 1899; Cascades of the Columbia, E. Hall, 1871.

This widely distributed species is extremely variable, but is usually readily recognized. In the middle West hundreds of acres of lowland are occupied almost exclusively by this grass, which when cut early makes a fair but coarse hay. It has been successfully employed in the manufacture of twine and coarse paper and makes an excellent and durable thatch. Its strong creeping rootstocks adapt it to binding loose sands and river banks subject to wash.

A small form of this species evidently connects it with *Spartina gracilis* Trin., and is represented by the following specimens:

Specimens examined.—*Wyoming:* Deer Creek, 2715 T. A. Williams, July 28, 1897; Beulah, 415 D. Griffiths, Aug. 5, 1897. *Idaho:* St. Anthony, 46 E. D. Merrill, Aug. 12, 1900.

2. **SPARTINA POLYSTACHYA** (Michx.) Willd. Enum. 81. 1809, in obs. (*Trachynotia polystachya* Michx. Fl. Bor. Am. **1**: 64. 1803; *Limnetis polystachya* Rich. in Pers. Syn. **1**: 72. 1805; *Spartina cynosuroides major* Trin. Agrost. **1**: 92. 1840. *Spartina cynosuroides polystachya* Scribn. Bull. Torr. Bot. Club, **10**: 86. 1883, in obs.; Beal, Grasses N. A. **2**: 398. 1896.)

A stout, erect, glabrous perennial, 12 to 18 dm. high, with long, flat leaves and terminal panicles of 20 to 60 crowded ascending spikes 5 to 12 cm. long. Culms often 2 cm. in diameter below, from stout rootstocks. Sheaths imbricate, crowded at the base; ligule a ciliate fringe about 3 mm. long; leaf-blades very long, the uppermost often 6 dm. in length, 8 to 24 mm. wide, strongly scabrous on the margins and more or less scabrous on the nerves on the upper surface, long-attenuate. Panicles 20 to 40 cm. long, the rachis channeled, scabrous; spikes usually crowded, ascending, the lower ones with a peduncle 1 to 2 cm. long, the upper ones sessile, rachis flattened, strongly scabrous on the margins. Spikelets 10 to 14 mm. long, densely imbricate; empty glumes lanceolate, attenuate to a rigid point, glabrous, except on the strongly aculeolate-scabrous keels, or rarely somewhat scabrous throughout, the second 10 to 14 mm. long, 2 to 3 times as long and much wider than the first; flowering glume 7 to 10 mm. long, ovate-lanceolate, obtuse, of similar texture as the empty glumes and similarly ciliate on the keel, rarely scabrous throughout. Palea exceeding the flowering glume, less firm in texture, somewhat obtuse or truncate.

Specimens examined.—*New Jersey:* Granton, W. M. Van Sickle, Aug. 25, 1895; Hackensack, G. V. Nash, Aug. 25, 1889; no locality, J. Holmes, 1890. *Delaware:* Deakyneville, 261 A. Commons, Oct. 8, 1897. *Virginia:* Suffolk, 444 F. L. J. Boettcher, Sept. 12, 1893; Norfolk, 294 T. H. Kearney, jr., Aug. 5, 1895. *North Carolina:* Wilmington, 266 T. H. Kearney, jr., Aug. 3, 1895; Neuse River, G. McCarthy, July 9, 1884. *Alabama:* Mobile, 22 T. H. Kearney, jr., July 3, 1895. *Florida:* No locality, A. W. Chapman; Jacksonville, 3433, A. H. Curtiss, August, 1883; 5518 Curtiss, Aug. 17, 1895; 5149 Curtiss, Aug. 28, 1894; Apalachicola, 102 T. H. Kearney, jr., July 15, 1895. *Mississippi:* Biloxi, 4543 S. M. Tracy, July 6, 1898; Ocean Springs, J. Skehan, September, 1895.

General distribution: In brackish marshes along the coast from New Jersey to Florida and Mississippi, July to October.

Type locality: "Hab. in inundatis maritimis, a Nova Anglia ad Floridam."

This species is related to *Spartina cynosuroides*, but is distinguished by its usually taller and stouter culms, broader leaves, more numerous spikes, absence of awns to the empty glumes, and in the percurrent midnerve of the entire, not cleft, flowering glume.

Michaux, in the original description of this species, gives its range as from New England to Florida, in which he has been followed by later botanists, the range given in the manuals extending as far north as the coast of Maine. None of the northern material examined is *Spartina polystachya* as here interpreted, but is referable to the closely related *S. cynosuroides*. One reason, perhaps, why these two species have been more or less confused is that *Spartina polystachya* has been interpreted to include forms which are evidently referable to *Spartina cynosuroides* and our restriction of the name to the southern form here considered is apparently the only logical course to follow. *Spartina polystachya* is abundantly distinct from *S. cynosuroides*, and there is no reason why the two species should be confused.

3. **SPARTINA GLABRA** Muhl. Gram. 54. 1817. (*Dactylis maritima* Walt. Fl. Carol. 77. 1788, not Curt. Enum. Brit. Gr. 4. 1785; *Limnetis glabra* Nutt. Gen. **1**: 38. 1818; *Spartina lævigata* Bosc in Link, Jahrb. **3**: 92. 1820; *Spartina lævigata* Willd. in Trin. Agrost. **1**: 91. 1840; *Spartina stricta glabra* A. Gray, Man. Bot., ed. 2, 552. 1856; *Spartina stricta maritima* Scribn. Mem. Torr. Bot. Club, **5**: 45. 1894.)

A glabrous, erect, and often stout salt-marsh grass 6 to 24 dm. high, with long, flat, or involute leaves, few or many erect, usually appressed spikes and glabrous spikelets. Culms simple, sometimes 2 cm. in diameter below; sheaths glabrous, the lower ones crowded and imbricate, distichous; ligule a ciliate ring about

2 mm. long; leaf-blades 5 to 7 dm. long, 1 to 1.5 cm. wide, usually flat but sometimes involute, tapering to a long involute tip, glabrous throughout. Panicles 2 to 4 dm. long, usually strict; rachis glabrous. Spikes 5 to 15 cm. long. Spikelets densely imbricate, 10 to 14 mm. long; empty glumes glabrous, or both sparingly scabrous on the keel, the first 6 to 8 mm. long, the second 10 to 14 mm. in length; flowering glume 8 to 10 mm. long. Palea somewhat exceeding the glume and thinner in texture.

GENERAL DISTRIBUTION: In salt marshes along the coast from Virginia to Florida and Texas, also in California. July to October.

TYPE LOCALITY: "Habitat in maritimis, Delaw. N. Ebor."

SPECIMENS EXAMINED.—*Virginia:* Virginia Beach, 3095 T. A. Williams, Sept. 23, 1900. *Florida:* Jacksonville, 5331 A. H. Curtiss, Aug. 28, 1894; also 5577 Curtiss, Oct. 17, 1895; Cedar Keys, 771 R. Combs, Aug. 1, 1898; Homosassa, 941 Combs, Aug. 10, 1898; Braidentown, 1295 Combs, Sept. 3, 1898; Bay Head, 631 Combs, Aug. 23, 1898; Palmetto, 2437, 2437a G. V. Nash, Aug. 21–23, 1895. *Mississippi:* Biloxi, 3854, 3855 S. M. Tracy, Sept. 16, 1897. *Louisiana:* Bayou Hermitage, 92 A. B. Langlois, Oct. 4, 1883. *Texas:* Corpus Christi, 105 G. C. Nealley, August, 1892. *California:* Salt flats, Chollas Valley, San Diego, 569 C. R. Orcutt, July 31, 1882; Newport, 1402, S. B. & W. F. Parish, October, 1882.

This species has been considered as a variety of the European *Spartina stricta* by recent American botanists, but we consider the earlier authors correct in holding it specifically distinct. *Spartina stricta* (Ait.) Roth, has been credited to North America, but a careful examination of all available European and American material leads us to conclude that this species does not extend to North America. Although the European plant occupies the same habitat as the American plant so referred, it is at once distinguished by its rather densely pilose glumes. In *Spartina glabra* the glumes in the typical form are perfectly glabrous, sometimes scabrous on the keel, but never pilose.

3*α*. **SPARTINA GLABRA ALTERNIFLORA** (Lois.) (*Spartina stricta alterniflora* A. Gray, Man. Bot., ed. 2, 552. 1856; *Spartina alterniflora* Lois. Fl. Gall. **2**: 719. 1807; *Trachynotia alterniflora* Steud. Nom. ed. 2, **2**: 695. 1840.)

Similar to the species in habit of growth, but differing in its sparingly pilose flowering glumes and few-flowered, slender spikes, the spikelets barely overlapping instead of being densely imbricate.

GENERAL DISTRIBUTION: In salt marshes along the coast. Maine to New Jersey. (Europe.)

TYPE LOCALITY: "Habitat circa Baionam, in pascuis limosis ad ripas aturi."

SPECIMENS EXAMINED.—*Maine:* Portland, H. W. Merrill, 1897; Cape Elizabeth, 819 E. E. Gayle, July, 1895. *Massachusetts:* Salem, J. H. Sears, 1883; Cambridge, L. H. Bailey, 1883. *New Jersey:* Atlantic City, F. Lamson-Scribner, August, 1895.

The form here described is identical with several sheets in the U. S. National Herbarium from the coast of France, labeled *Spartina alterniflora*, which is considered as worthy of specific rank by European botanists. Its close relationship to *Spartina glabra* is at once evident, and it presents an intermediate form between that species and the next variety.

3*β*. **SPARTINA GLABRA PILOSA** var. nov. (*Spartina stricta* of American authors, not Roth.)

Like the species in habit of growth, but differing in its sparingly pilose flowering glumes, in this respect approaching the European *Spartina stricta*. Empty glumes aculeolate scabrous on the keels.

GENERAL DISTRIBUTION: In similar localities as the species, from Massachusetts to North Carolina.

SPECIMENS EXAMINED.—*Rhode Island:* Providence, S. T. Olney. *New Jersey:* Atlantic City, F. Lamson-Scribner, August, 1895 (type), also L. F. Ward, Sept. 7, 1884; Weehawken, W. M. Van Sickle, Aug. 20, 1895. *Maryland:* Ocean City, 264 A. Commons, Sept. 16, 1880. *Delaware:* Deakyne's Landing, 265 Commons, Oct. 8, 1897; Delaware City, 266 Commons, Aug. 20, 1874. *Virginia:* Hampton, G. McCarthy, Aug. 31, 1883; Lynnhaven Bay, 2112 T. H. Kearney, jr., Oct. 3, 1898; Fort Monroe, G. Vasey, 1878. *North Carolina:* Ocracoke Island, 2308 T. H. Kearney, jr., Oct. 13–17, 1898; no locality, G. McCarthy, September, 1888.

This variety is distinguished from the species by its sparingly pilose flowering glumes and strongly aculeolate scabrous keels and from the variety *alterniflora* by its densely imbricate spikelets. This form approaches the European *Spartina stricta*, but is distinguished by its much less pilose glumes.

4. **SPARTINA FOLIOSA** Trin. Agrost. **1**: 92. 1840. (*Spartina leiantha* Benth. Bot. Voy. Sulph. 56. 1844.)

A glabrous perennial with numerous, rather short flat leaves, densely flowered spikes and usually very strongly aculeolate-ciliate keeled empty glumes. Culms simple, about 1 cm. in diameter below. Sheaths crowded and overlapping, especially above; ligule a ciliate ring about 2 mm. long; leaf-blades 2 to 3 dm. long, about 1 cm. wide, glabrous throughout, plane or sometimes involute in drying, tapering into a slender involute tip. Panicle 10 to 15 cm. long, almost cylindrical, the spikes densely flowered, 2 to 5 cm. long, appressed, primary, and secondary axes glabrous. Spikelets imbricate, 12 to 14 mm. long, glabrous throughout or the empty glumes usually very strongly aculeolate-ciliate on the keels, the first narrow, 7–8 mm. long, the second, 12 to 14 mm. in length; flowering glume nearly as long as the second empty glume, slightly shorter than the palea, glabrous throughout or sometimes ciliate on the margins below.

GENERAL DISTRIBUTION: In salt marshes along the coast. California, August to September.

TYPE LOCALITY: "California."

SPECIMENS EXAMINED.—*California:* San Francisco, 124 Bioletti, September, 1891; Oakland, 18 J. W. Blankinship, Aug. 11, 1891; Alameda, J. Burtt Davy, August, 1896; San Diego, 274 E. Palmer, September, 1888; Reclamation, Alice Eastwood, 1897.

This species was based on a specimen collected in California, but has previously been considered as a synonym of *Spartina stricta.* It is closely related to *Spartina glabra,* but is distinguished by its numerous comparatively short leaves, which are crowded on the upper portion of the culm, dense, almost cylindrical spike-like panicles and (usually) the very prominently aculeolate-ciliate keels of the empty glumes. In the original description Trinius describes the spikelets as being glabrous, and in this respect the specimen collected by Davy, cited above, agrees with his description, most of the spikelets being glabrous, although occasionally some of them are sparingly aculeolate-scabrous on the keels of the empty glumes. In all other respects, however, this specimen agrees with the others cited above, in which one of the most prominent distinguishing characters is the prominently aculeolate-ciliate keels of the empty glumes, and which is evidently the common form of the species.

This species is useful in reclaiming salt marshes, and in several places about San Francisco Bay it has modified the coast line and increased the acreage of many farms. The town of Reclamation received its name from the fact that in that vicinity many acres of land have been reclaimed chiefly by the use of this grass.

5. **SPARTINA JUNCIFORMIS** Engelm. & Gray, Bost. Journ. Nat. Hist. **5**: 238. 1845. (*Vilfa spartinæ* Trin. Agrost. **1**: 60. 1840; *Spartina gracilis* Chapm. Fl. So. U. S. 556. 1860; *Spartina gouini* Fourn. Mex. Pl. 135. 1881; *Spartina densiflora* Beal, Grasses N. Am. **2**: 397. 1896, not Brongn.; *Spartina multiflora* Vasey in Beal l. c. 400, in obs.)

A stout glabrous perennial 6 to 18 dm. high with very long narrow involute leaves and short appressed spikes, which form a spike-like inflorescence 10 to 30 cm. long. Sheaths glabrous, the lower ones mostly shorter than the internodes, the upper ones exceeding them; ligule a ciliate fringe; leaf-blades rigid, those of the sterile shoots 3 to 6 dm. long. Panicle tapering to the apex; spikes 30 to 50, 2 to 5 cm. long, sessile, imbricate. Spikelets 6 to 8 mm. long, densely imbricate; empty glumes ciliate-hispid on the keel, the first linear obtuse or acute, shorter than the second, which is truncate and short-awned or emarginate; flowering glume slightly longer than the first glume, rather thin in texture, and ciliate-scabrous on the keel. Palea slightly exceeding the glume in length.

General distribution: In brackish marshes along the coast from Florida to Texas and Mexico. April to October.

Type locality: "Saline prairies near the coast" (Texas).

Specimens examined.—*Florida:* Key West, Blodgett, also J. H. Simpson, June, 1891; Apalachicola, 119 T. H. Kearney, jr., July 16, 1895; Palma Sola Bay, J. H. Simpson, 1890; Hamosassa, 937 R. Combs, Sept. 10, 1898; Cedar Key, 785 Combs, Sept. 2, 1898; no locality, A. W. Chapman (sub. nom. "*Spartina gracilis* of So. Flor." *Mississippi:* Ocean Springs, 133, 134 S. M. Tracy, Sept. 15, 1889; Biloxi, 3783, 3784 S. M. Tracy, Sept. 19, 1897, also 234 T. H. Kearney, jr., Oct. 5, 1896; Bayou St. Louis, 91 A. B. Langlois, Sept. 13, 1883. *Texas:* Eagle Pass, 83 V. Havard, 1882; Meskit Bay, 66 H. W. Ravenel, Apr. 28, 1869; Galveston, L. F. Ward, Sept. 16, 1877; Hockley, F. W. Thurow; Cotula, 30, 33 E. N. Plank, 1891; no locality, G. C. Nealley, 1889. *Mexico:* Hacienda de Angostura, San Luis Potosi, 3760 C. G. Pringle, July 10, 1891.

This very distinct species is readily recognized by its dense spike-like panicles and very narrow involute leaves. Beal based his description of *Spartina densiflora* on No. 3760 Palmer, cited above, which is identical with the forms referred to *Spartina junciformis* Engelm. & Gray, in the same work. *Spartina densiflora* Brongn., has been questionably referred to *Spartina junciformis* Engelm. & Gray as a synonym, but according to Chilean material, collected and determined by Philippi, it is not at all related to that species. The specimen from Philippi is evidently related to *Spartina glabra*, but is apparently distinct from any North American species. It is doubtless identical with *Spartina ciliata* Kunth. *Spartina gouini* Fourn., was based on No. 72 Gouin, from Vera Cruz, Mexico, and although we have not been able to examine this specimen, Fournier's full description leaves no doubt as to the identity of his species.

Vilfa spartinæ Trin. was based on a specimen from Texas, and is, so far as known, the earliest description of the species, and a strict interpretation of the Rochester Rules would make the name *Spartina spartinæ* (Trin)., certainly a meaningless combination. There is in the U. S. National Herbarium a fragment from Trinius's type which was received from the St. Petersburg Academy of Natural Sciences, which clears up any doubt that might exist as to the identity of that species.

6. **SPARTINA GRACILIS** Trin. Agrost. **1**: 88. 1840.

A comparatively slender glabrous perennial 3 to 9 dm. high from creeping, scaly, rootstocks, with flat leaves and 3 to 9 rather short, appressed spikes 2 to 5 cm. long. Culm simple; sheaths, at least the lower ones, exceeding the internodes; ligule a ciliate fringe about 1 mm. long; leaf-blades 1 to 3 dm. long, 2 to 6 mm. wide, plane, or often involute, at least when dry, rigid, scabrous on the margins and upper surface, glabrous beneath, long involute-attenuate. Panicle 10 to 20 cm. long, the common rachis glabrous or nearly so, somewhat undulate; spikes appressed, pale or purplish, the lower ones usually somewhat pedunculate, the upper ones sessile or nearly so. Spikelets 6 to 9 mm. long, densely imbricate;

empty glumes acute, aculeolate-ciliate on the keels and also commonly on the adjacent nerves, the first about one-half as long as the acute second one; flowering glume obtuse, slightly shorter than the second and about equaling the obtuse palea, aculeolate-ciliate on the keel.

General distribution: Meadows, swamps, and river bottoms, especially in alkaline soils. North Dakota to Kansas, west to British Columbia, Nevada, and California. April to October.

Type locality: "Amer. bor. (*Hooker*, s. n. *Sp. cynosuroidis*)."

Specimens examined.—*North Dakota:* Minnewaukon, 64 M. A. Brannon, July 17, 1896. *South Dakota:* Aberdeen, 125 D. Griffiths, July, 1896, 842 Griffiths, 1897; Indian Creek, Williams & Wilcox, Aug. 24, 1891. *Kansas:* Syracuse, 110 C. H. Thompson, July 13, 1893. *Montana:* Choteau, 301 Griffiths & Lange, Aug. 22, 1900; Glendive, L. F. Ward, July 15, 1883; Missoula, 265 Williams & Griffiths, 1898; Dillon, 2080 P. A. Rydberg and 335 C. L. Shear, July 3, 1895; Manhattan, 2204 Rydberg and 446 Shear, July 18, 1895; Townsend, 2152 Rydberg, July 15, 1895; East Gallatin Swamps, 3194 Rydberg, July 24, 1896; Upper Big Horn River, 180 J. W. Blankinship, August, 1890; Hound Creek, 329 F. Lamson-Scribner, July 29, 1883; Billings, 235 Williams & Griffiths, Aug. 31, 1898; Buffalo, 105 Williams & Griffiths, Aug. 4, 1898. *Wyoming:* Granger, 3885 A. Nelson, July 30, 1897; Pine Bluffs, 3630 Nelson, July 6, 1897; Laramie County, 2843 Nelson, August, 1896; Otto, 2867 T. A. Williams, Aug. 7, 1897; Belle Fourche River, 2714 Williams, July 28, 1897; Green River, 2328 Williams, July 8, 1897; Yellowstone Park, 3606 Rydberg & Bessey, Aug. 4, 1897. *Colorado:* Canyon City, 985 C. L. Shear, Aug. 10, 1896; Saguache Creek, 1111 J. Wolfe, 1873. *Idaho:* No locality, 3701 L. F. Henderson, 1895; 523 Hayden's expedition, 1872. *Utah:* Rabbit Valley, 353 L. F. Ward, June 10, 1875; Lake Park, S. M. Tracy, Aug. 9, 1887. *Nevada:* No locality, Wheeler, 1872; Reno, M. E. Jones, June 8, 1897; Ash Meadows, 364 Coville & Funston, March 2, 1891; Soda Springs, 323 W. H. Shockley, June, 1882; Unionville Valley, 1298 S. Watson, October, 1867. *California:* Inyo County, 1002 Coville & Funston, June 20, 1891. *Oregon:* Alvord Lake, 2437 J. B. Leiberg, July 1, 1896; no locality, 627 E. Hall, 1871. *Washington:* Douglas County, 2248 L. F. Henderson, July 11, 1892; Loomiston, 891 A. D. E. Elmer, August, 1897; no locality, 248 Sandberg & Leiberg, 1893. *British Columbia:* Kamlooks, 9 J. Macoun, June 13, 1889; *Alberta*, Benton Trail, J. Macoun, July 17, 1895. 13319 Herb. Geol. Surv. Canad.

This widely distributed species is related to *Spartina cynosuroides*, but is readily distinguished by its much smaller size, shorter and narrower leaves, fewer, shorter spikes, much shorter spikelets, and merely acuminate empty glumes, not awned as in that species. Beal[a] refers a specimen from Mississippi to this species, which is evidently an error, and at the same times cites *Spartina junciformis* Engelm. & Gray as a synonym, while on the succeeding page of the same work *S. junciformis* Engelm. & Gray, is properly considered as a distinct species.

7. **SPARTINA JUNCEA** (Michx.) Willd. Enum. 81. 1809. (*Trachynotia juncea* Michx. Fl. Bor. Am. **1**: 64. 1803; *Limnetis juncea* Rich. in Pers. Syn. **1**: 72. 1805; *Dactylis cynosuroides* Walt. Fl. Carol. 77, 1788, non Linn; *Spartina americana* Roth. in Trin. Agrost. **1**: 87. 1840 as syn.; *Spartina versicolor* Fabre (?) Ann. Sci. Nat. III. **13**: 123. *t. 3.* 1849; *Spartina caespitosa* A. A. Eaton Bull. Torr. Bot. Club, **25**: 338. 1898).

A rather stout, tufted, glabrous perennial 5 to 12 dm. high from a usually stout rootstock with numerous long, involute, erect, or ascending leaves and exserted panicles and 2 to 8 erect or spreading, pale or purplish spikes. Culms usually stouter than in *S. patens*, the lower sheaths overlapping; ligule a fringe of hairs; leaf-blades glabrous, except on the upper surface, involute, erect, or ascending, 1.5

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[a] Grasses N. A. **2**: 399. 1896.

to 6 dm. long, or the upper ones somewhat shorter. Panicle exserted, common rachis glabrous or scabrous on the margins. Spikelets densely imbricate, 7 to 10 mm. long; first glume linear, mucronate, usually strongly scabrous on the keel above, 4 to 5 mm. long; second glume lanceolate, acute or acuminate, 7 to 10 mm. long, strongly scabrous on the keel and adjacent nerves and sometimes slightly scabrous on the broad thin margins; flowering glume 6 to 7 mm. long, ovate, obtuse, slightly emarginate at the apex, glabrous or scabrous on the keel above. Palea slightly exceeding the flowering glume, glabrous or nearly so.

GENERAL DISTRIBUTION: In salt meadows and sandy beaches along the coast from New Hampshire to Florida and Texas. May to September.

TYPE LOCALITY: "Hab. in siccis maritimis Carolinae, Georgiae."

SPECIMENS EXAMINED.—*New Hampshire:* Seabrook, 505 A. A. Eaton, Aug. 27, 1891, also September, 1896, sub nom. *Spartina caespitosa. Massachusetts:* Salisbury, 587 A. A. Eaton, Sept. 7, 1896, sub nom. *Spartina caespitosa;* Cambridge, 30 W. W. Bailey, August, 1871. *New Jersey:* Cape May, 263 A. Commons, Aug. 20, 1872; Atlantic City, F. Lamson-Scribner, Aug. 29, 1895, also L. F. Ward, Sept. 7, 1884. *Delaware:* Deakyne's Landing, 262 A. Commons, June 20, 1866. *Maryland:* Baltimore, Dr. Foreman, 1873. *Virginia:* Lambert Point, 1694 T. H. Kearney, jr., July 16, 1898; Cape Henry, 1815 Kearney, July 26, 1898; Norfolk, 307 Kearney, Aug. 5, 1895; Virginia Beach, 1052 A. A. Heller, July 12, 1893, also 3106 T. A. Williams, Sept. 23, 1900. *North Carolina:* Near Wilmington, 153 F. V. Coville, June 27, 1890; Smiths Island, 3516a Biltmore Herbarium, July 14, 1897. *Alabama:* Mobile, 57 T. H. Kearney, jr., July 8, 1895. *Florida:* Jacksonville, 15, 20 R. Combs, July 18, 1898, also 4948 A. H. Curtiss, July 17, 1894; Palmetto, 2439 G. V. Nash, Aug. 21–23, 1895; St. George Island, 131 T. H. Kearney, jr., July 17, 1895; Miami, A. P. Garber 1877; Avondale, 498 Combs, Aug. 16, 1898; Apalachicola, 103, 118 Kearney, July 15, 1895; Braidentown, 1326a Combs, Sept. 3, 1898; Crystal, 1007 Combs, Sept. 16, 1898; Bay Head, 656 Combs, Aug. 23, 1898. *Louisiana:* Pointe à la Hache, 89 A. B. Langlois, June, 1879. *Mississippi:* Biloxi, 1566 S. M. Tracy, July 27, 1891; Chandeleur Island, 4542 Tracy, June 30, 1898; Ocean Springs, 132 Tracy, Sept. 15, 1889; Border of Wolf River, 90 A. B. Langlois, July, 1880; Ship Island, 1087 C. L. Pollard, July 28, 1896, also S. M. Tracy, May 29, 1898, and July 20, 1894. *Texas:* Corpus Christi, 67 G. C. Nealley, August, 1892, also June, 1893.

We believe *Spartina juncea* to be a valid species, for the extreme form is most distinct from *Spartina patens*, to which it has previously been referred. The most striking differential characters are its greater size, much longer, erect or ascending leaves and stouter rootstocks. The spikelets are usually acute, or at least much less acuminate than in *S. patens*, although little dependence can be placed on spikelet characters in this extremely variable group. Michaux based his species on material from Carolina and Georgia, and from his description evidently had small specimens; there can, however, be no doubt as to what form he had in mind. The typical southern form ranges certainly as far north as New York, and we believe Eaton's *Spartina caespitosa* should properly be referred to *S. juncea*, as we can find no valid characters on which to separate the species, the slight variation from typical *Spartina juncea* being evidently that due entirely to habitat. *Spartina versicolor* Fabre, from southern Europe, is evidently identical with our Atlantic coast form here referred to *Spartina juncea.*

The characters on which we have separated *Spartina juncea* from *S. patens* were drawn entirely from herbarium material, and it is very probable that field observations may yield more and better differential characters than here enumerated, and at the same time prove some characters here given invalid.

8. **SPARTINA PATENS** (Ait.) Muhl. Gram. 55. 1817. (*Dactylis patens* Ait. Hort. Kew. 104. 1789; *Spartina pumila* Roth. Cat. **3**: 10. 1806.)

A rather slender, glabrous, very wiry perennial 3 to 8 dm. high, from long, usually slender rootstocks, with 2 to 6 slender, purplish spikes and widely spreading involute leaves. Sheaths mostly inclosing the culms; ligule a fringe of hairs; leaf-blades spreading, 1 to 3.5 dm. long, involute, glabrous, except on the upper surface. Panicle slightly exserted or often somewhat inclosed in the upper sheath, common axis glabrous, spikes spreading or ascending, 2 to 5 cm. long. Spikelets densely imbricate, the first glume about 4 mm. long, linear, mucronate, nearly glabrous; second glume lanceolate, acuminate, 10 to 12 mm. long, scabrous on the keel and adjacent nerves, glabrous on the broad, thin margins; flowering glume 5 to 6 mm. long, ovate obtuse, thin, glabrous, except on the strongly scabrous keel, slightly emarginate. Palea exceeding the glume, similar in texture, but glabrous throughout, or only sparingly scabrous on the keel above.

General distribution: In salt meadows and sands along the coast, from Newfoundland and Nova Scotia to Maryland and possibly farther South. July to August.

Type locality: "Nat. of North America."

Specimens examined.—*New Brunswick:* St. Andrews, J. Fowler, Aug. 16, 1900. *Maine:* Cape Elizabeth, F. Lamson-Scribner, July 26, 1895; Two Bush Island, Penobscot Bay, F. L. Harvey, Aug. 21, 1896. *Massachusetts:* Newbury, 516 A. A. Eaton, Aug. 29, 1896; no locality, W. P. Conant. *Connecticut:* Bridgeport, E. H. Eames, July 25, 1894, July 19, 1898. *New York:* Wading River, Long Island, E. S. Miller, July 23, 1877. *New Jersey:* Weehauken, W. M. Van Sickle, July 8, 1895. *Maryland:* Bay Ridge, F. Lamson-Scribner, Sept. 3, 1897; also F. H. Knowlton, July 13, 1897.

Dactylis patens Ait., was based on material from North America, the name referring to the spreading leaves. There is little doubt as to northern form here considered, being identical with Aiton's species, and was so considered by Muhlenberg, who believed *Spartina patens* and *Spartina juncea* to be distinct, although later authors considered them to be identical. *Spartina patens* is closely related to *S. juncea*, but is distinguished by its usually much smaller size, shorter, widely spreading leaves, smaller rootstocks, and usually more acuminate spikelets.

9. **SPARTINA BAKERI** sp. nov.

A rather stout glabrous, tufted perennial, 12 to 16 dm. high, with few rigid erect culms and numerous strongly involute leaves 6 to 18 dm. in length, but some of the culm leaves much shorter. Sheaths very close, the lower ones overlapping; ligule a ciliate fringe; leaf-blades rigid, strongly involute, glabrous beneath, strongly scabrous above and on the margins, 4 mm. wide or less when flattened out. Panicle 12 to 18 cm. long, consisting of 5 to 12 appressed purplish spikes 3 to 6 cm. long, common rachis glabrous or slightly scabrous on the margins, partial rachis flattened and scabrous on the margins. Spikelets densely imbricate; empty glumes acuminate, scabrous on the keels, the first very narrow, about 4 mm. long, the second 8 to 10 mm. long; flowering glume about 6 mm. long, scabrous above and on the keel, glabrous below. Palea equaling the glume in length, similar in shape, but of thinner texture, slightly scabrous on the keel above.

Type specimen collected on the east shore of Lake Ola, Tangarene, Florida, No. 14, C. H. Baker, April 19, 1898.

Specimens examined.—*Florida:* Merritts Island, G. L. Bates, March, 1889; Heath, Bates, April, 1889; Cedar Key, 772 R. Combs, Aug. 1, 1898; Jacksonville, 16 Combs, July 18, 1898.

This species is related to *Spartina juncea*, and its floral characters are very similar to that species. It is distinguished, however, by its vegetative characters, its much greater size and very long leaves, and evidently develops much earlier. The following note is based on field observations of Mr. Baker:

"This form grows on lake margins in large and conspicuous tussocks from a few inches to five feet in diameter. Leaves at first erect, but soon recurved and spreading, very numerous, involute and harsh, the longest six and one-fourth feet in length. Culms comparatively few. This grass between seasons sends up culms which do not develop inflorescence, as far as noted, and although it has been observed frequently and at all seasons I have never before seen it in bloom, and consider it very irregular in this respect; it is abundant locally, and predominates over considerable areas about Lake Munroe. The leaves of this grass are persistent and exhibit great durability under exposure to the weather, and while not as abundant as 'wire-grass,' 'rush-grass,' as this species is known, can still be obtained in considerable quantities, and may prove to be of considerable economic importance."

This species has previously been considered as a form of *Spartina patens* (Ait.) Muhl., but is certainly very distinct from that species and from *Spartina juncea* (Mx.) Willd.

Doubtful species.

SPARTINA SCHREBERI J. F. Gmelin in Linn. Syst. Nat. ed. 13, **2**: 123. 1791.

This species is credited to North America in Index Kewensis, but we do not know on what authority, as Gmelin based the species entirely on Schreber's generic description and neither Gmelin nor Schreber cite any locality. The genus was doubtless based on the European *Spartina stricta*, and this being the case *Spartina schreberi* should be considered as a synonym of that species.

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 10.
B. T. GALLOWAY, Chief of Bureau.

RECORDS OF SEED DISTRIBUTION

AND

COOPERATIVE EXPERIMENTS WITH GRASSES AND FORAGE PLANTS.

BY

F. LAMSON-SCRIBNER, Agrostologist.
GRASS AND FORAGE PLANT INVESTIGATIONS.

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WASHINGTON:
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1902.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., December 26, 1901.

SIR: I have the honor to transmit herewith the manuscript of a paper entitled Records of Seed Distribution and Cooperative Experiments with Grasses and Forage Plants, by F. Lamson-Scribner, Agrostologist, and recommend its publication as Bulletin No. 10 of the Bureau series.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

This bulletin relates to the collection and distribution of seeds of grasses and forage plants by the Department of Agriculture through the Office of the Agrostologist, formerly Division of Agrostology, and to cooperative work in grass and forage plant investigations with a number of State experiment stations to whom these seeds were sent. The manner of keeping the records of this seed distribution is explained in detail, and the plan of conducting the cooperative experiments and the line of work or forage problem taken up with each station are fully given. This work was put into operation last year in compliance with an act of Congress, and has proven so satisfactory to all concerned that it has been continued the present year, although there are now no statutory regulations requiring that it should be.

F. LAMSON-SCRIBNER,
Agrostologist.

OFFICE OF THE AGROSTOLOGIST,
Washington, D. C., November 29, 1901.

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RECORDS OF SEED DISTRIBUTION AND COOPERATIVE EXPERIMENTS WITH GRASSES AND FORAGE PLANTS.

PURCHASE AND COLLECTION OF SEEDS, ROOTS, AND SPECIMENS.

House bill No. 121, Fifty-sixth Congress, first session, making appropriations for the United States Department of Agriculture, contained the following clause:

> *Provided,* That six thousand dollars of the amount hereby appropriated [for grass and forage plant investigations] be used to purchase and collect seeds, roots, and specimens of valuable and economic grasses and forage plants to be distributed to the various experiment stations in the several States and Territories, to be by them used, under the direction of the Secretary of Agriculture, to ascertain their adaptability to the various soils and climates of the United States.

In carrying out the plans necessary to meet this provision in the bill making appropriations for the Agricultural Department, Mr. C. L. Shear, an assistant in the Division of Agrostology, was put in charge of the seed and field work July 1, 1900, when the law making the appropriations went into effect. Mr. Shear was instructed to make collections of seeds of the valuable native grasses and forage plants and was directed to secure in quantity seeds of wild range grasses, also those species of probable value in the South for winter pasturage, those likely to prove good meadow grasses for high altitudes, and of those adapted to binding drifting sands. In carrying out this work it not infrequently happened that long, tedious journeys had to be made to regions inaccessible to stock before grasses in seed could be found and collections made. As a result of this work in the field during the season 4 tons of seed of about 130 varieties of grasses and forage plants were gathered, the quantities varying from 1 pound to 500 pounds. A list of the varieties of seeds gathered, with notes upon some of the more important species, was presented in Circular No. 9, issued from the office of the Secretary in December, 1900. In conducting the cooperative work with the stations, which will be referred to later, it was necessary to supplement this amount of seeds of native varieties by purchasing from dealers seeds of the more important tame grasses and forage plants which the experiments called for.

COOPERATION WITH THE STATIONS AUTHORIZED.

In the House bill referred to above, making appropriations for the Department of Agriculture for 1900–1901, there was this clause:

> And the agricultural experimental stations are hereby authorized and directed to cooperate with the Secretary of Agriculture in establishing and maintaining experimental grass stations for determining the best methods of caring for and improving meadows and grazing lands, the use of different grasses and forage plants, their adaptability to various soils and climates, the best native and foreign species for reclaiming the overstocked ranges and pastures, for renovating worn-out lands, for binding drifting sands and washed lands, for turfing lawns and pleasure grounds, and for solving the various forage problems presented in the several sections of our country.

In order to carry out this feature of the law, the Secretary of Agriculture, through the recommendation of the Agrostologist, directed Mr. Thomas A. Williams, then assistant chief of the Division of Agrostology, to visit the several experiment stations, especially those in the Western States, to study the forage problems of most importance to each, and by consulting with the directors of the stations to arrange plans for carrying on cooperative work with them with the view of solving the problems determined upon.

LINES OF INVESTIGATIONS OF FORAGE PROBLEMS.

Mr. Williams says in his report, published as Circular No. 8 (revised), of the office of the Secretary:

> In brief, this series of visits to the stations demonstrates clearly not only that there are many problems which can be studied much better through station and Departmental cooperation, but that the station authorities themselves appreciate the desirability of such cooperative work and are eager to enter into it. It is recognized that in these general problems, while the stations are able to work out the details of experiments and matters of relatively local bearing, there is a most important phase of the investigations that can be much more satisfactorily handled by the Department, and, in order to secure the best results to the country at large, it is highly desirable that there should be the closest cooperation between stations and Departmental investigations. In addition to the assistance which the Department can render the stations in solving these special problems through the detailing of its experts for field investigations and supplying seed for experiments, this cooperation will have a most important bearing on the work of the stations in encouraging greater concentration on lines of greatest importance to the people and in rendering more readily available to the station workers the experience and training of the Departmental experts.
>
> Consultation with the station authorities has emphasized the desirability of cooperation along a number of lines of investigation, the following being perhaps the most important at the present time and including every section of the country.
>
> (1) The formation, care, and management of pastures, including the selection of the best varieties, methods of preparing the soil and of planting the seed, and after treatment of grass lands, including grazing, rest, fertilizing, and cultivation.
>
> (2) Range improvement, or the best methods of bringing up the natural grass ands of the great range regions of the country and maintaining them in the condition of greatest productivity, including the improvement of the native grass cover by reseeding, alternation of rest and grazing periods, scarifying, etc.

(3) Alkali-resistant crops, particularly those best adapted to furnishing forage that can be used to supplement the native ranges.

(4) Cover crops for soils liable to wash, which will at the same time afford a supply of forage or can be turned under for green manure.

(5) A continuous soiling series for use in sections where the dairying industry is paramount.

(6) Winter pasturage for the South and Southwest.

(7) Sand-binding grasses for the coast regions and along the Great Lakes.

(8) Meadow crops for higher altitudes, particularly in the Rocky Mountain States, where, although pasturage is abundant, crops that will produce profitable amounts of hay are greatly needed.

(9) Supplementary forage crops, particularly those with a short season of growth, that can be grown in rotation with wheat, cotton, and other primary crops, either for forage or for the improvement of the soil fertility.

(10) Drought-resistant crops for arid sections.

(11) The selection and development of improved varieties of grasses and forage crops adapted to special conditions and uses.

As a result of visiting the State stations, and through correspondence, it has been ascertained that cooperative work can be arranged for the investigation of each of these problems with one or more stations most advantageously situated, and there is no question as to urgent need of such investigations.

ARTICLES OF COOPERATION.

A plan was devised to carry on this work under articles of cooperation signed by the station officials and officials of this Department, of which the following are presented as examples:

Articles of cooperation in investigations on improvement of the Northwestern ranges between the ——————— Agricultural Experiment Station and the Division of Agrostology, United States Department of Agriculture.

The object of these investigations shall be to find the best and most practical way of improving the forage conditions in the dry sections of the Northwest, and specially of renewing the worn-out ranges and devising methods of managing them whereby the highest degree of productivity may be maintained. The following plan of cooperation is agreed upon:

1. The ——————— Experiment Station to procure a suitable tract of range land; to undertake immediate supervision of the work through a member of its official staff; and to furnish all implements, fencing, etc., required by the investigations, the same to be the sole property of the station when this cooperative arrangement is dissolved.

2. The U. S. Department of Agriculture, through the Division of Agrostology, to assist in selecting the land and in planning and conducting these investigations; to furnish seed of native and introduced grasses and forage plants for experiments on said tracts, and pay other expenses connected with the investigations, not to exceed ——————— in any one fiscal year, it being understood that under the appropriation act the Department can not assume responsibility for the continuance of its contribution beyond June 30, 1901.

3. The investigations conducted under this cooperative agreement shall be planned conjointly by the representatives of the ——————— Experiment Station and the Division of Agrostology, officially charged with the work, subject to the approval of the proper authorities in each case.

4. Both parties to this agreement shall be free at any time to use the results obtained in these investigations in their official correspondence and publications, giving proper credit to the fact that such results have been secured by cooperative work.

——— ———,

Director ——————— *Experiment Station.*

——— ———,

Chief Division of Agrostology.

Approved:

——— ———,

Secretary of Agriculture.

Articles of cooperation in grass and forage plant investigations between the ——————— *Agricultural Experiment Station and the Divison of Agrostology, United States Department of Agriculture.*

The object of these investigations shall be to find the best crops for supplying forage to supplement the natural ranges and for the improvement of cultivated lands. The following plan of cooperation is agreed upon:

1. The ——————— Experiment Station to provide land at the home station, or at outlying representative points in that territory, upon which to make said experiments, and to undertake the immediate care and supervision of the work.

2. The U. S. Department of Agriculture, through the Division of Agrostology, to furnish all seeds necessary in making these experiments, and to otherwise assist in planning and conducting said investigations.

3. The investigations conducted under this cooperative agreement shall be planned conjointly by the representatives of the ——————— Experiment Station and the Division of Agrostology officially charged with the work, subject to the approval of the proper authorities in each case.

4. Both parties to this agreement shall be free at any time to use the results obtained in these investigations, giving proper credit to the fact that such results have been secured by cooperative work.

——— ———,

Director ——————— *Experiment Station.*

——— ———,

Chief Division of Agrostology.

Approved:

——— ———,

Secretary of Agriculture.

The following is the form in use since the organization of the Bureau of Plant Industry:

Articles of cooperation in grass and forage plant investigations between the Wyoming State Experiment Station and the Bureau of Plant Industry, United States Department of Agriculture.

The subject of these investigations shall be grasses and forage plants for alkali soils and arid lands.

1. The Wyoming Experiment Station to furnish the land necessary for the said experiments, to undertake the immediate supervision and care of the work, and to assist in planning the investigations.

2. The United States Department of Agriculture, through the Bureau of Plant Industry, Office of Grass and Forage Plant Investigations, to assist in planning and conducting the said investigations, and to furnish all seeds necessary for making the experiments.

3. The investigations conducted under this cooperative agreement shall be planned conjointly by the representatives of the Wyoming Experiment Station and the Bureau of Plant Industry, officially charged with the work, subject to the approval of the proper authorities in each case.

4. Both parties to this agreement shall be free, at any time, to use the results obtained in these investigations in their official correspondence and publications, giving proper credit to the fact that such results have been secured by cooperative work.

Elmer E. Smiley,
Director Wyoming Experiment Station.
B. T. Galloway,
Chief Bureau of Plant Industry, United States Department of Agriculture.

At the present time fifteen of the experiment stations are working in cooperation with the Department on one or more of the lines connected with grass and forage plant investigations.

SEED DISTRIBUTION.

Since the organization of the Division of Agrostology seeds of grasses and forage plants have each year been distributed to the agricultural experiment stations and to many individual experimenters. The following table shows the number of packages of seed so distributed during the fiscal years 1896–1901, inclusive; the total number of packages sent to the experiment stations during this time being 4,166, and to individuals 9,377, or a total of 13,543 packages (see Table I). These for the most part were seeds which were obtained through the direct efforts of the employees of the Division by collections in the field. During the fiscal year 1900–1901 there were distributed to the experiment stations 16,101¼ pounds of seed, embracing 171 varieties, as shown in Tables II and III.

Table I.—*Number of packages of seed distributed to the experiment stations and to individuals during the fiscal years 1896 to 1901, inclusive, or for five years, through the Division of Agrostology.*[a]

Distribution.	1896 to 1897.	1897 to 1898.	1898 to 1899.	1899 to 1900.	1900 to 1901.	Total for the five years.
Total number of packages sent to experiment stations	2,281	184	462	292	947	4,166
Total number of packages sent to individuals	632	2,749	1,739	2,709	1,548	9,377
Total number of packages distributed	2,913	2,933	2,201	3,001	2,495	13,543

[a] This does not include the packages distributed to foreign countries.

TABLE II.—*Amount (in pounds) of seeds of grasses and forage plants distributed to the experiment stations and to individuals in the several States and Territories in cooperation with the stations during the fiscal year 1900–1901.*

States and Territories.	Seeds sent to experiment stations.	Seeds sent to individuals in cooperation with the experiment stations.	Total weight seeds distributed to each State.
	Pounds.	*Pounds.*	*Pounds.*
Alabama	....	30	30
Arizona	710	....	710
Arkansas	....	257½	257½
California	....	46¼	46¼
Colorado	444	242½	686½
Connecticut	....	108	108
Delaware	171	....	171
Florida	....	51½	51½
Georgia	....	142	142
Idaho	130	23¾	153¾
Illinois	133	283½	416½
Indiana	....	20	20
Iowa	....	6½	6½
Kansas	1,145	456½	1,601½
Kentucky	30	262½	292½
Louisiana	135	14	149
Maine	65	128	193
Maryland	360	518¾	878¾
Massachusetts	....	214¼	214¼
Michigan	380	53	433
Minnesota	....	119	119
Mississippi	10	65½	75½
Missouri	691½	244¾	936¼
Montana	193½	227¾	421¼
Nebraska	249¼	231¾	481
New Hampshire	3,700	134	3,834
New Jersey	75	238	313
New Mexico	563	76½	639½
New York	81½	137	218½
North Carolina	773	80	853
North Dakota	485	169	654
Nevada	202	41	243
Ohio	100	75½	175½
Oklahoma	30	10¾	40¾
Oregon	670½	218¼	888¾
Pennsylvania	....	214¼	214¼
Rhode Island	50	....	50
South Carolina	17½	78¼	95¾
South Dakota	307¼	208¾	516
Tennessee	440¾	252	692¾
Texas	752½	117¾	870¼
Utah	35	32¼	67¼
Virginia	107	359⅓	466⅓
Washington	1,695	43	1,738
West Virginia	30	3⅓	33⅓
Wisconsin	125	64	189
Wyoming	1,014	751	1,765
Total	16,101¼	7,051½	23,152¾

Table III.—*Varieties of grasses and forage plants, seeds of which were distributed through the Division of Agrostology in 1900–1901, the amount in pounds of each variety sent out, both to the experiment stations and to individuals in cooperation with the stations, and the total amount distributed.*

Variety.		Sent to stations.	Sent to individuals.	Total distributed.
Latin name.	English name.	*Pounds.*	*Pounds.*	*Pounds.*
Agropyron caninum	Bearded wheat grass	23½	22	45½
Agropyron divergens	Bunch wheat grass	10	12	22
Agropyron occidentale	Western wheat grass	491½	86¼	577¾
Agropyron richardsoni	Richardson's wheat grass	1		1
Agropyron riparium	Riparian wheat grass	5		5
Agropyron spicatum	Bunch wheat grass	428	54½	482½
Agropyron tenerum	Slender wheat grass	428¼	82½	510¾
Agropyron violaceum		1½		1½
Agrostis alba	Red top	274½	72½	347
Agrostis canina	Rhode Island bent	18	55	73
Agrostis stolonifera	Creeping bent	8	5¼	13¼
Alopecurus occidentale	Mountain foxtail	2		2
Alopecurus pratensis	Meadow foxtail	18	10	28
Aristida humboldtiana	Humboldt's triple-awn	1¼		1¼
Aristida fasciculata	Triple-awn	¼		¼
Ammophila arenaria	Beach grass	167	93½	260½
Andropogon saccharoides	Feather beard grass	186¼	25	211¼
Anthoxanthum odoratum	Sweet vernal grass	1		1
Arrhenatherum elatius	Tall oat grass	244	28	272
Atriplex canescens	Shad scale	11½	5½	17
Atriplex confertifolia	Spiny saltbush	2		2
Atriplex eremicola		20¼	3	23¼
Atriplex halimoides	Gray saltbush	49	17¼	66¼
Atriplex holocarpa	Annual saltbush	12½	6½	19
Atriplex nuttallii	Nuttall's saltbush	43	23¼	66¼
Atriplex pabularis		11		11
Atriplex semibaccata	Australian saltbush	108	67¾	175¾
Atriplex truncata	Utah saltbush	12		12
Atriplex volutans	Tumbling saltbush	21½	2¼	23¾
Avena sativa	Winter oats	21	14	35
Beckmannia erucæformis	Slough grass	25		25
Bouteloua oligostachya	Blue grama	129¼	18	147¼
Bouteloua bromoides	Brome grama	10		10
Bouteloua curtipendula	Side-oats grama	52¾	6	58¾
Bouteloua eriopoda	Woolly-foot grama	5¼		5¼
Bouteloua hirsuta	Bristly grama	1¼		1¼
Bouteloua humboldtiana	Humboldt's grama	5		5
Bouteloua polystachya	Low grama	72¼	¼	72½
Brassica napus	Rape	13	35¼	48¼
Bromus inermis	Awnless brome grass	459	744½	1,203½
Bromus marginatus	Short-awned brome grass	154	13	167
Bromus pallidus		9		9
Bromus polyanthus	Many-flowered brome	19		19
Bromus pumpellianus	Mountain brome grass	½		½
Bromus richardsoni	Richardson's brome	9		9
Bromus schraderi	Schrader's brome	1		1
Bromus unioloides	Rescue grass	322½	91½	414
Bulbilis dactyloides	Buffalo grass (roots only)			
Calamagrostis canadensis var	Canada blue joint	5	1	6
Calamovilfa longifolia	Sand grass	7	1	8

TABLE III.—*Varieties of grasses and forage plants, etc.*—Continued.

Variety.		Sent to stations.	Sent to individuals.	Total distributed.
Latin name.	English name.			
		Pounds.	*Pounds.*	*Pounds.*
Carex macrocephala	Big head sedge	9	132	141
Chætochloa composita	Arizona millet	5¼		5¼
Chætochloa italica	German millet	20	49½	69½
Chætochloa italica var	Golden wonder millet		½	½
Chloris elegans		11¼		11¼
Cicer arietinum	Gram or chick pea	2	4	6
Cynodon dactylon	Bermuda grass	20	50¼	70¼
Cynosurus cristatus	Crested dog's tail	7	29½	36½
Dactylis glomerata	Orchard grass	424	130	554
Dactyloctenium australiense	Button grass	25	3	28
Deschampsia caespitosa	Tufted hair grass	2		2
Desmodium tortuosum, var	Beggarweed	2	½	2½
Desmodium sp	Perennial beggarweed	¾		¾
Eatonia obtusata		1		1
Eleusine coracana	African millet	5		5
Elymus ambiguus		5	2	7
Elymus arenarius	Sea rye grass	6	3	9
Elymus canadensis	Canada rye grass	167½	15	182½
Elymus canadensis var	do	56¾	6	62¾
Elymus condensatus	Giant rye grass	49½	9	58½
Elymus glabriflorus	Smooth-flowered rye grass	9¾		9¾
Elymus glaucus	Mountain rye grass	15¼	4	19¼
Elymus macounii	Macoun's rye grass	11		11
Elymus simplex	Alkali rye grass	17	3	20
Elymus virginicus submuticus	Short-awned rye grass	86	1½	87½
Eragrostis neo-mexicana	Mexican love grass	13		13
Eriochloa punctata	Everlasting grass	2½		2½
Eriocoma cuspidata	Indian millet	83	8	91
Erodium cicutarium	Alfilaria	6	5	11
Ervum lens	Lentils	1		1
Euchlæna mexicana	Teosinte	22	54¾	76¾
Eurotia lanata	Winter fat	8¼	¼	8½
Festuca arundinacea	Reed fescue	41		41
Festuca duriuscula	Hard fescue	17	3	20
Festuca elatior	Meadow fescue	405½	257¼	662¾
Festuca heterophylla	Various-leaved fescue	1	15	16
Festuca kingii	King's fescue	7½	½	8
Festuca ovina	Sheep's fescue	6½	63	69½
Festuca rubra	Red fescue	24	65	89
Festuca thurberi	Thurber's fescue	3		3
Glycine hispida	Soy bean	361½	304	665½
Helianthus sp	Sunflower			
Hilaria cenchroides	Curly mesquite	7		7
Hilaria mutica	Black galleta	9¼		9¼
Hordeum vulgare	Barley	12		12
Kœleria cristata	Prairie June grass	2		2
Lathyrus sativus	Bitter flat pea	115	216	331
Leptochloa dubia		13¼		13¼
Lespedeza striata	Japan clover	32	20	52
Lolium italicum	Italian ray grass	117	145½	262½
Lolium perenne	Perennial ray grass	298	35	333
Lycurus phleoides	Texas timothy	16½		16½
Medicago denticulata	Bur clover	154	38	192

TABLE III.—*Varieties of grasses and forage plants, etc.*—Continued.

Variety.		Sent to stations.	Sent to individuals.	Total distributed.
Latin name.	English name.			
		Pounds.	*Pounds.*	*Pounds.*
Medicago maculata		2	5	7
Medicago sativa	Alfalfa	1,371	1,501½	2,872½
Medicago sativa turkestanica	Turkestan alfalfa	6	57	63
Medicago sativa var	Oasis alfalfa	11		11
Melilotus alba	Sweet clover	80½	28	108½
Melinis minutiflora	Molasses grass	28		28
Mucuna utilis	Velvet bean	47	4	51
Muhlenbergia racemosa	Wild timothy			
Muhlenbergia gracilis		¾		¾
Onobrychis sativa	Sainfoin	138½	21	159½
Panicularia americana	American manna grass	3	10	13
Panicum bulbosum	Turnip grass	14		14
Panicum bulbosum var	do	4¾		4¾
Panicum crus-galli	Barnyard grass	715½	368½	1,084
Panicum miliaceum	Broom-corn millet	1,226	230¾	1,456¾
Panicum obtusum		3¼	12	15¼
Panicum texanum	Colorado grass	370	177	547
Pappophorum apertum		½		½
Paspalum compressum	Carpet grass	2	2	4
Paspalum dilatatum	Large water grass	8½	3½	12
Phalaris arundinacea	Reed canary grass	10	11½	21½
Phaseolus mungo	Green gram	23		23
Phaseolus retusus	Metcalfe bean	7¾	1½	9¼
Phaseolus sp	Vallo bean	2		2
Phleum asperum	Sand timothy	½		½
Phleum pratense	Timothy	618	172½	790½
Pisum arvense	Russian blue field pea	72	91½	163½
Pisum sativum var	Black marrow-fat pea	62	60	122
Poa compressa	Canada blue grass	93½	50½	144
Poa fendleriana	Mutton grass	2		2
Poa glaucifolia	Glaucous blue grass	1		1
Poa laeviculmis	Smooth-stemmed blue grass	4½		4½
Poa laevigata	Smooth blue grass	15		15
Poa lucida	Shining blue grass	46	2	48
Poa macrantha	Sea-side blue grass	177½	156½	334
Poa nevadensis	Nevada blue grass	4		4
Poa pratensis	Kentucky blue grass	366½	77	443½
Poa trivialis	Rough-stalked blue grass	4½	10	14½
Poa wheeleri	Wheeler's blue grass	7½	1	8½
Poterium sanguisorba	Burnet	75½	26	101½
Puccinellia airoides	Alkali spear grass	16		16
Rumex sp	Dock	2		2
Sorghum vulgare var	Kafir corn	12	13½	25½
Sorghum vulgare var	Colman cane	6		6
Sorghum vulgare var	Early amber cane	6	3	9
Sorghum vulgare var	Early orange cane	6		6
Sorghum vulgare var	Folger's cane	6		6
Secale cereale	Winter rye	122		122
Sporobolus airoides	Fine saccaton	29½		29½
Sporobolus cryptandrus	Dropseed	12¼	3	15¼
Sporobolus depauperatus	Steel grass	3		3
Sporobolus wrightii	Wright's saccaton	29¼	3½	32¾

TABLE III.—*Varieties of grasses and forage plants, etc.*—Continued.

Variety.		Sent to stations.	Sent to individuals.	Total distributed.
Latin name.	English name.			
		Pounds.	*Pounds.*	*Pounds.*
Sporobolus wrightii var		10		10
Stipa viridula		2¼		2¼
Stipa sp		5		5
Triodia mutica		¼		¼
Trifolium alexandrinum	Egyptian clover	10	3	13
Trifolium hybridum	Alsike clover	7¾	100	107¾
Trifolium incarnatum	Crimson clover	2	56¼	58¼
Trifolium medium	Mammoth clover	10	65	75
Trifolium pratense	Red clover	615	42	657
Trifolium repens	White clover	135	11	146
Triticum spelta	Spelt	21	17	38
Vicia maritima	Seaside vetch	18		18
Vicia villosa	Hairy vetch	309	228	537
Vigna catjang	Cowpea	2,180½	150½	2,331
Vigna catjang var	Black cowpea	204		204
Zea mays	Indian corn	22½	6	28½
Zizania aquatica	Wild rice		2	2
Total		16,101¼	7,051½	23,152¾

NOTE.—Total varieties, 171.

SEEDS TO PRIVATE INDIVIDUALS.

Many applications were made to the Secretary of Agriculture by individuals for seeds of grasses adapted to special conditions for purely experimental purposes. In order to meet these requests and to keep all of our work in line of cooperation with the experiment stations, the following letter was addressed to the directors of the several stations under date of January 31, 1901:

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE AGROSTOLOGIST,
Washington, D. C., January 31, 1901.

SIR: Requests for seeds of grasses and forage plants for special purposes are received by this Department from many private individuals throughout the country and prior to the current fiscal year the Secretary has, so far as possible, generously responded to these requests. For the most part they have come from intelligent and progressive farmers who had definite objects in view and whose reports relative to the seeds sent them have oftentimes been of great value. A record has been kept of every package of seed thus sent out and we have classed the parties as our "volunteer experimenters" and our cooperation with them, costing only the seed sent, has been mutually advantageous. We would be glad to continue this line of work and hope that you will enable us to do so and respectfully ask your cooperation in the matter. If agreeable to you, we will refer all applications for seeds and grasses and forage plants made by individuals in your State to you by addressing them a letter like the inclosed (marked 1). If they then should write to you and you deem it wise for us to honor their request, the seeds will be forwarded, so far as our supply will permit. We will notify you of the shipment of the seed on a card similar to the inclosed (marked 2), which is our preliminary step in the record. We could, if you wish, send seed in quantity to you to be redirected to individuals in your State from your station. In such case we would expect you to furnish us the addresses of the parties to whom the seed was sent and the amount in each case. At the close of each season we send blanks (marked 3) to every individual to whom seeds have been sent from this office for the purpose of obtaining a report as to the results of the experiments or progress made. We arrange with every one receiving seeds in the way here described to report results to this office and we will, upon your request, send you duplicate copies of these reports and thus share with you in all the results obtained. I would be pleased to have an expression from you in regard to this plan of cooperation with individuals.

Respectfully,
F. Lamson-Scribner,
Agrostologist.

Agricultural Experiment Station,
Manhattan, Kans.

The scheme proposed in this communication met with very favorable reception on the part of the experiment stations, as will be seen by the replies here quoted, which are in the main expressions of all those received.

Washington Agricultural College and School of Science,
Pullman, Wash., February 8, 1901.

Dear Sir: I am in receipt of your favor of January 31, and note carefully the plan outlined therein for the distribution of seeds of grasses and forage plants in the several States. The plan you propose meets with my approval and will have the hearty cooperation of this station.

Yours, very truly,
E. A. Bryan, *President.*

F. Lamson-Scribner,
Agrostologist, Department of Agriculture, Washington, D. C.

The Pennsylvania State College
Agricultural Experiment Station,
February 19, 1901.

Dear Sir: Replying to yours of January 31, relative to the matter of distribution of seeds and forage plants, I beg to say that it would give this station pleasure to accept your very courteous and generous proposal in regard to cooperation. If you will refer applicants to us as requested, we will be very glad to advise you as to the matter of honoring their requests and to receive from you the duplicate reports of results.

Very respectfully, yours,
H. P. Armsby, *Director.*

Mr. F. Lamson-Scribner,
United States Department of Agriculture, Washington, D. C.

The total amounts of seeds thus distributed to individuals in each State is shown in Table II, and the total quantity of each variety of seed so distributed is shown in Table III.

SYSTEM OF KEEPING RECORDS.

In order to bring all this work into such shape that the results might be utilized by both the stations and the Department, the following plan of records was adopted. Upon the receipt of an application from a correspondent in any given State, the following letter was sent to the applicant:

U. S. DEPARTMENT OF AGRICULTURE,
GRASS AND FORAGE PLANT INVESTIGATIONS, DIVISION OF AGROSTOLOGY,
Washington, D. C., ———, *1901.*

DEAR SIR: Your letter of ———, addressed to ——— ———, has been referred to this division. The law (House bill No. 121, Fifty-sixth Congress, first session, making appropriations for the Department of Agriculture) requires that all seeds of grasses and forage plants distributed by this division for experimental use be sent to the experiment stations. We will be pleased to honor, so far as possible, any requests for seeds made through the director of your agricultural experiment station, located at ———. Please state definitely to the director the object of your request.

Respectfully,

F. LAMSON-SCRIBNER,
Agrostologist.

If the request was indorsed by the director of the experiment station a card was then made out in accordance with the following blank, directing the shipping clerk to send the seed, and when the shipment was made this card was returned to the office of the Agrostologist and filed for record.

State: ———. ———, 1901.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF PLANT INDUSTRY,
WASHINGTON, D. C.

COOPERATIVE EXPERIMENTS IN GRASS AND FORAGE PLANT INVESTIGATIONS WITH ——— EXPERIMENT STATION.

Name and address of experimenter: ———.
Variety of seed and amount sent: ———.
Source and age of seed: ———.
Object of experiment: ———.
Date of shipment: ———.

At the same time a card, the form of which is shown below, was sent to the director of the experiment station, advising him of the shipment, and this card was designed for filing at the station:

COOPERATIVE EXPERIMENTS IN GRASS AND FORAGE PLANT INVESTIGATIONS.

U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

——— ———
EXPERIMENT STATION

Name and address of experimenter: ———.
Variety of seed and amount sent: ———.
Source of seed: ———.
Object of experiment: ———.
Seeds shipped ———, 190—. Report received ———, 190—.

When seeds were sent to any individual under this plan he was advised of the fact by the following letter, in which the nature of final report expected from the correspondent was outlined. We found this to be important, for in many cases when we had called for reports as to results of seeds distributed the party receiving them often said that he wished he had known earlier the nature of the report wanted, and he would have taken the necessary notes. This letter was designed to cover this ground.

U. S. DEPARTMENT OF AGRICULTURE,
GRASS AND FORAGE PLANT INVESTIGATIONS,
Washington, D. C., ———, *190–*.

DEAR SIR: In accordance with arrangements made with the director of the agricultural experiment station of your State for conducting cooperative experiments with grasses and forage plants, the following seeds are being sent to you:

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------------------------------------ ------------------------------------
------------------------------------ ------------------------------------

In sending you these seeds it is understood that you will try them in an experimental way to test their adaptability to your section or their special value. It is further understood that you will give them all the care necessary to meet the requirements of the experiment and report the result obtained on blanks which will be furnished you at the proper time. These reports will be filed in this office and copies will be sent to the director of your State experiment station. The following are the principal points to be noted:

Conditon and preparation of soil.
Date and method of planting.
Method of cultivation, if any.
Date of full bloom.
Date of ripening.
Date and method of harvesting.
Quality of the product.
Yield per acre of forage or seed, or both.
Stand and amount of growth made.
Value of the plant as food for stock.
Also any other miscellaneous notes of economic interest.

The seed produced by native and introduced plants, not obtainable from seedsmen, should be carefully saved.

Respectfully,

F. LAMSON-SCRIBNER,
Agrostologist.

Mr. ———.

At the close of the season blanks for reports of the form here presented will be sent to everyone who received seeds. Copies of these reports will be sent to the directors of the experiment stations in the States where the experimenters are located.

UNITED STATES DEPARTMENT OF AGRICULTURE.

GRASS AND FORAGE PLANT INVESTIGATIONS.

EXPERIMENTS WITH GRASSES AND FORAGE PLANTS.

Report on varieties cultivated at ———. [*Name town, county, and State.*]

Common name, ———. Latin name, ———.
Kind, condition, and preparation of soil, ———.
Date and method of planting, ———.
Cultivation, if any, ———.
Date and method of harvesting and stage of maturity reached when harvested, ———.
Date of full bloom, ———. Date of ripening, ———.
Yield per acre (if practicable), ———.
Quality of product, ———.
Notes on growth, ———.
Your opinion of the value of the plant as feed for stock, ———.
Name of experimenter, ———. Post-office, ———. County, ———. State, ———.

[On reverse.]

GENERAL REMARKS.

190—.

(State.)

Name of experimenter:

Post-office:

County:

VARIETY.

(Common name.)

(Latin name.)

UNITED STATES DEPARTMENT OF AGRICULTURE,
GRASS AND FORAGE PLANT INVESTIGATIONS.

Report on grass and forage plant investigations.

INSTRUCTIONS.

Kindly fill out this blank, reporting each variety separately, and return in the inclosed franked and addressed envelope. No postage required.

The final record of distribution is kept upon a card, the face and reverse side of which is herewith shown. Only one species is entered on this card, and the cards are filed in alphabetical order. The amount we have on hand is shown at any time, together with the amount distributed, and to whom.

		RECEIVED FROM—	AMT. LBS.
Agropyron tenerum (Slender wheat grass).	12	Griffiths & Lange	31½

Fiscal year 1900–1901.

July.		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May.		June.	
D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.	B.

[Reverse.]

Date.	Amount.	Name.	Post-office.	State.
Feb. 25	5	Walter J. Hovey	Fort Pierre	S. Dak.
Feb. 27	10	Luther Foster	Laramie	Wyo.
Feb. 28	10	James Withycombe	Corvallis	Oreg.

It may interest some to note the form of our accession cards, which is shown herewith:

DATA.

Seeds of—
Agropyron tenerum. Collector's No. ———.
(Slender wheat grass). Distribution No. 21.

From Griffiths & Lange. Locality, Billings, Mont. Date, July 14, 1900. Altitude ———. Amount, pounds, 31½.
Habit of growth, ———.
Character of soil, ———.
Use ———.

By this system of records the Office of the Agrostologist has full data in regard to all seeds received or sent out, and it is possible to show at any time the variety or amount sent to any experiment station or to any individual in cooperation with the station. The totals of these amounts for the fiscal year 1900–1901 are shown in Tables II and III.

Table IV contains a list of those experiment stations with which the Department of Agriculture, through the Office of the Agrostologist, is carrying on cooperative experiments in grass and forage plant investigations. This is a list of the stations with which the Department is working during the current fiscal year, for, although the law cited specifically directing the stations to cooperate with the Secretary of Agriculture along these lines is no longer in force, it having been omitted from the bill making appropriations for the Department during the present year, it has been deemed best to continue the work, apparently so well begun under the bill of last year.

TABLE IV.—*List of experiment stations with which articles of cooperation have been signed.*

State.	Object of investigations.	Department allowance.
Arizona[1]	For improving the forage conditions and renovating the ranges.	Seeds and funds.
California	The planting and testing of sand-binders	Do.
Colorado	Grass and forage plants for alkali and arid soils	Do.
Kansas	The best method of pasture and range improvement	Do.
Maryland	To find the best crops for use in securing a continuous soiling.	Seeds only.
Michigan	To find the best grasses for fixing the drifting sands along the Great Lakes and to determine the possibility of converting these into lands productive of forage and other crops.	Do.
Missouri	To find the best method for the formation and management of meadows and pastures in the Middle Western States.	Do.
Nebraska	Growing and testing of native and cultivated grasses for the Great Plains region.	Do.
New Hampshire	Improvement and renovation of worn-out hay and pasture land.	Seeds and funds.
New Mexico	Forage crops to supplement ranges and the improvement of cultivated lands.	Seeds only.
Oregon	To find the best sand-binding grasses and to determine the possibility of rendering sandy lands productive of both grasses and forage plants.	Seeds and funds.
South Dakota	For testing drought-resisting forage plants with a view to finding varieties suitable for use in the range region.	Do.
Tennessee	Formation and management of pastures and meadows in Middle Southern States.	Seeds only.
Texas	Formation of meadows and pastures in the Middle Southern States.	Seeds and funds.
Washington	For improving forage conditions and renewing worn-out ranges.	Do.
Wyoming	Forage plants for arid and alkali lands	Seeds only.
Delaware	Cover crops for orchards	Do.
Utah	Forage plants for arid and alkali lands	Do.

[1] Not renewed for 1901-2.

Since this work of cooperation was first inaugurated the Bureau of Plant Industry, which includes the Office of the Agrostologist, has been established, and the new articles of cooperation now in force have been slightly modified from those of last year to meet the new terms of expression required by this new organization, and a similar modification has been made in the letter addressed to individual applicants for seeds, as will appear from the copy presented below, which is that of the form now used:

U. S. DEPARTMENT OF AGRICULTURE, BUREAU OF PLANT INDUSTRY,
GRASS AND FORAGE PLANT INVESTIGATIONS, OFFICE OF THE AGROSTOLOGIST,
Washington, D. C.,———, 190–.

DEAR SIR:

Your letter of ———, addressed to ———, requesting seeds, has been referred to this office. The Department of Agriculture is conducting experiments with grasses and forage plants in your State in cooperation with your agricultural experiment station located at ———. In order to continue the plans already made we would ask you to kindly present your request through the director of your experiment station. We will be glad to honor, so far as possible, all such requests. Please state definitely to the director of the station the object of your request.

Respectfully,

F. Lamson-Scribner, *Agrostologist.*

CONCLUSION.

Thus far our plan of cooperation with the stations in grass and forage plant investigations and the manner of keeping our records, as above described, have been quite satisfactory, but it is not unlikely that some changes or improvements may be made as the work progresses. Doubtless the work can be rendered more effective and more certain of useful results if an official of the Department can be located at those stations where important cooperative work is being carried on. This officer may be a scientific aid—and we are already employing scientific aids in this way—or he may be someone more experienced. In any case, he should be given immediate charge of the work, to which he should give his whole time while at the station. During some months of the year, especially during the winter season, he could spend his time at the Department in order to familiarize himself with our methods and make up his reports. It is to be regretted that the important work of grass and forage plant investigations has not more funds available for conducting this cooperative work on a larger, more effective, and more striking scale.

I have only to add that I wish to give expression here to our most sincere regrets at the loss of Mr. Thomas A. Williams, in whose charge this cooperative work had been placed and who had so successfully carried out the ideas of the Department while engaged upon it. The present season Prof. A. S. Hitchcock has been placed in charge of this work and has visited many of the stations and made a special study of the conditions existing where cooperative work is being carried on.

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